Radiological Health Data

VOLUME V, NUMBER 6

JUNE 1964

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Pertinent original data and interpretive papers are invited from investigators. Accepted material will be appropriately credited. The reports are reviewed by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Health, Education, and Welfare
Atomic Energy Commission
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Contributions may be sent to the Radiological Health Data and Reports Staff, Division of Radiological Health, Public Health Service, Washington 25, D.C.

For further information on any subject reported in this issue, readers are referred to the contributors indicated in article headings.

RADIOLOGICAL HEALTH DATA

VOLUME V, NUMBER 6
JUNE 1964

TABLE OF CONTENTS

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis of alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided this month by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also shown by beta concentration isograms in figure 4.

1. Radiation Surveillance Network, February 1964

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which gathers samples from 74 stations distributed throughout the country (figure 1). During February, a new station, Montgomery, Alabama, was added to the network. Most of the stations are operated by State health department personnel trained in procedures necessary to obtain the measurements as described and presented below.

The alerting function of the Network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network station operators regularly report their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. These field estimates are reported monthly (*1*).

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a 38,700 pc Sr^{90}–Y^{90} standard.[1] Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula (*2*).[2] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*1*). The sample with the highest activity for February was from Las Vegas, Nevada (collected on Febru-

[1] The Sr^{90}–Y^{90} source currently used as a standard was used from April 1962 to August 1963 as 40,000 pc total activity. Beginning with September 1963 data the nominal activity of the standard was adjusted for decay (about 2½ percent per year) to 38,700 pc.

[2] $AT^{1.2}=C$, where A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at $T=1$.

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, FEBRUARY 1964

ary 5), with an activity of 5.2 pc/m³. Eighteen other samples with activities exceeding 3.5 pc/m³ were collected: Phoenix, Arizona (2/10, 2/11, 2/12, 2/27); Los Angeles, California (2/3, 2/4, 2/21); Jacksonville, Florida (2/1); Miami, Florida (2/1, 2/18); Sante Fe, New Mexico (2/16, 2/29); Las Vegas, Nevada (2/1, 2/24, 2/26); and El Paso, Texas (2/13, 2/14, 2/16). All of these samples indicated an age of more than 100 days.

The February 1964 fission-product beta concentrations in surface air (extrapolated to the time of collection) are given in table 1. RSN data, along with Canadian and Mexican air data, are represented by isograms in figure 4. The RSN network average for February (1.09) showed a slight increase over the January average (0.94), significant at the 95 percent confidence level. This may be an early influence of the spring rise, which is evidenced by the general latitude[3] and fission product age of 19 samples with highest concentration mentioned above.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m², C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The February 1964 average concentrations and total depositions are given in table 2.

[3] See discussion of spring rise in report by Lockhart, *et al.*, in this issue, page 255.

TABLE 1.—FISSION PRODUCTS GROSS BETA ACTIVITY IN SURFACE AIR, FEBRUARY 1964

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]
Alabama:	Montgomery [b]	19	1.69	0.27	1.22
Alaska:	Adak	28	1.07	<0.27	0.47
	Anchorage	28	1.47	0.11	0.68
	Attu	19	0.84	0.18	0.55
	Fairbanks	4	0.92	0.56	0.66
	Juneau	27	1.34	<0.10	0.41
	Kodiak	20	1.48	<0.10	0.55
	Nome	20	0.62	<0.10	0.39
	Point Barrow	28	1.02	0.12	0.36
	St. Paul Island	11	1.06	0.17	0.53
Ariz:	Phoenix	23	4.35	1.20	2.53
Ark:	Little Rock	27	2.23	0.43	1.17
Calif:	Berkeley	18	3.13	0.51	1.56
	Los Angeles	19	4.15	0.92	2.80
Canal Zone:	Ancon	15	0.90	0.12	0.54
Colo:	Denver	26	3.06	0.41	1.47
Conn:	Hartford	29	1.60	0.27	0.99
Del:	Dover	17	2.01	0.79	1.16
D. C:	Washington	27	2.36	0.20	1.12
Fla:	Jacksonville	29	3.63	0.40	1.44
	Miami	28	3.92	0.87	2.03
Ga:	Atlanta	22	1.50	0.40	0.77
Guam:	Agana	29	2.81	0.42	1.09
Hawaii:	Honolulu	29	1.90	0.25	0.90
Idaho:	Boise	29	2.65	0.15	0.95
Ill:	Springfield	22	1.23	0.32	0.70
Ind:	Indianapolis	28	1.44	0.34	0.92
Iowa:	Iowa City	28	1.35	0.30	0.81
Kans:	Topeka	26	2.59	0.46	1.14
Ky:	Frankfort	29	2.98	0.33	1.01
La:	New Orleans	29	1.86	0.44	1.07
Maine:	Augusta	29	1.85	0.24	1.13
	Presque Isle	25	1.49	0.33	0.90
Md:	Baltimore	19	1.61	0.33	0.93
	Rockville	15	3.35	<0.10	1.39
Mass:	Lawrence	29	1.83	0.22	1.11
	Winchester	26	1.54	0.14	0.97
Mich:	Lansing	29	1.92	0.65	1.25
Minn:	Minneapolis	28	2.03	0.31	0.84
Miss:	Jackson	29	2.29	0.41	1.27
	Pascagoula	0	—	—	—
Mo:	Jefferson City	28	1.57	0.35	0.72
Mont:	Helena	28	2.60	0.41	1.00
Nebr:	Lincoln	13	1.63	<0.10	0.95
Nev:	Las Vegas	25	5.20	0.55	2.50
N. H:	Concord	17	1.98	0.25	1.37
N. J:	Trenton	27	1.71	0.20	1.06
N. Mex:	Sante Fe	29	4.46	0.39	1.95
N. Y:	Albany	19	1.15	0.22	0.82
	Buffalo	27	1.72	0.48	1.19
	New York	27	1.78	0.39	0.99
N. C:	Gastonia	29	1.92	0.32	0.92
N. Dak:	Bismarck	29	2.30	0.45	0.91
Ohio:	Cincinnati	19	1.49	0.39	0.96
	Columbus	25	2.38	0.31	1.10
	Painesville	28	2.55	0.60	1.59
Okla:	Oklahoma	26	1.58	0.40	0.94
	Ponca City	27	1.24	0.21	0.64
Ore:	Portland	19	3.31	0.57	1.76
Pa:	Harrisburg	27	1.80	<0.10	0.69
P. R:	San Juan	29	1.22	0.23	0.62
R. I:	Providence	25	1.59	0.40	1.05
S. C:	Columbia	29	1.74	0.38	0.88
S. Dak:	Pierre	29	2.33	0.44	0.93
Tenn:	Nashville	29	2.98	0.42	1.05
Tex:	Austin	29	2.46	0.43	1.36
	El Paso	29	4.52	0.65	2.03
Utah:	Salt Lake City	28	3.37	0.44	1.31
Vt:	Barre	29	1.98	0.54	1.30
Va:	Richmond	29	1.60	0.26	0.78
Wash:	Seattle	29	1.36	0.15	0.69
W. Va:	Charleston	28	1.53	0.29	0.88
Wisc:	Madison	29	1.60	0.51	1.02
Wyo:	Cheyenne	27	3.46	0.40	1.61
Network summary		1829	5.20	<0.10	1.09

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] New station, began operation February 1, 1964.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, FEBRUARY 1964

Station location		Average concentration [a] (pc/liter)	Total deposition [a] (nc/m²)
Alaska:	Anchorage	260	1.9
	Fairbanks	[b]—	—
	Juneau	240	81.2
Ark:	Little Rock	280	22.2
Calif:	Berkeley	400	1.9
	Los Angeles	—	—
Colo:	Denver	—	—
Conn:	Hartford	450	15.6
D. C:	Washington	470	33.2
Fla:	Jacksonville	220	21.5
	Miami	290	29.5
Ga:	Atlanta	280	10.1
Hawaii:	Honolulu	300	3.9
Idaho:	Boise	—	—
Ill:	Springfield	330	5.0
Ind:	Indianapolis	420	21.6
Iowa:	Iowa City	380	8.3
Kans:	Topeka	1,000	12.0
Ky:	Frankfort	400	20.0
La:	New Orleans	230	24.7
Maine:	Augusta	370	25.8
	Presque Isle	—	—
Md:	Baltimore	560	11.2
Mass:	Lawrence	350	36.0
	Winchester	500	39.3
Mich:	Lansing	500	6.5
Minn:	Minneapolis	—	—
Miss:	Jackson	520	21.2
Mo:	Jefferson City	310	17.7
Mont:	Helena	990	13.8
Nebr:	Lincoln	—	—
Nev:	Las Vegas	—	—
N. J:	Trenton	390	6.7
N. Mex:	Santa Fe	560	16.7
N. Y:	Albany	230	9.2
	Buffalo	370	2.2
N. C:	Gastonia	260	33.5
N. Dak:	Bismarck	200	4.0
Ohio:	Columbus	880	28.2
	Painesville	800	33.7
Okla:	Oklahoma City	220	8.5
	Ponca City	440	8.3
Ore:	Portland	310	8.4
Pa:	Harrisburg	200	5.4
P. R:	San Juan	200	3.7
R. I:	Providence	500	16.0
S. C:	Columbia	340	41.4
S. Dak:	Pierre	—	—
Tenn:	Nashville	490	40.0
Tex:	Austin	300	12.0
	El Paso	—	—
Utah:	Salt Lake City	1,700	13.4
Vt:	Barre	480	9.6
Va:	Richmond	250	28.4
Wash:	Seattle	470	10.3
W. Va:	Charleston	440	32.3
Wisc:	Madison	500	2.4
Wyo:	Cheyenne	500	0.7

[a] The minimum concentration reported for a single sample is 200 pc/liter. If the individual sample has a concentration of <200 pc/liter, the deposition for that sample is calculated by $D=\frac{C\times P}{1000}=<0.2P$ in nc/m² (see text). A less-than sign (<) is used with the monthly total deposition whenever the sum of the individual less-than values represents more than 10 percent of the total. The monthly average concentration is then calculated as described in text, retaining the less-than sign when used with the total deposition.

[b] Dash indicates no evaporated sample received.

2. Canadian Air Monitoring Program[1] February 1964

Department of National Health and Welfare

As part of its Radioactive Fallout Study Program, the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four collection stations are located at airports (see figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for February 1964 are given in table 3 and presented in conjunction with U.S. and Mexican data by an isogram map (figure 4).

[1] Data from *Radiation Protection Programs*, 3:11–24, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (March 1964).

TABLE 3.—GROSS BETA ACTIVITY IN AIR, CANADA, FEBRUARY 1964

[Average concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	28	3.1	0.4	1.3
Coral Harbour	26	1.8	0.1	1.0
Edmonton	29	2.3	0.4	1.0
Ft. Churchill	29	1.4	0.4	0.9
Ft. William	29	2.3	0.2	1.1
Fredericton	29	1.7	0.1	1.0
Goose Bay	29	1.5	0.3	1.0
Halifax	27	2.0	0.2	1.2
Inuvik	29	2.0	0.5	0.9
Montreal	29	2.0	0.3	1.2
Moosonee	29	2.3	0.6	1.4
Ottawa	29	1.6	0.4	1.1
Quebec	28	1.6	0.4	1.2
Regina	29	1.8	0.5	0.9
Resolute	29	1.6	0.1	0.8
St. John's, Nfld	27	1.8	0.1	0.9
Saskatoon	29	1.9	0.5	1.1
Sault Ste. Marie	28	1.8	0.6	1.1
Toronto	29	0.9	0.1	0.4
Vancouver	27	2.3	0.1	0.9
Whitehorse	29	1.8	0.2	0.8
Windsor	23	1.8	0.4	1.2
Winnipeg	29	3.4	0.4	1.2
Yellowknife	28	1.7	0.4	0.9
Network summary	677	3.4	0.1	1.0

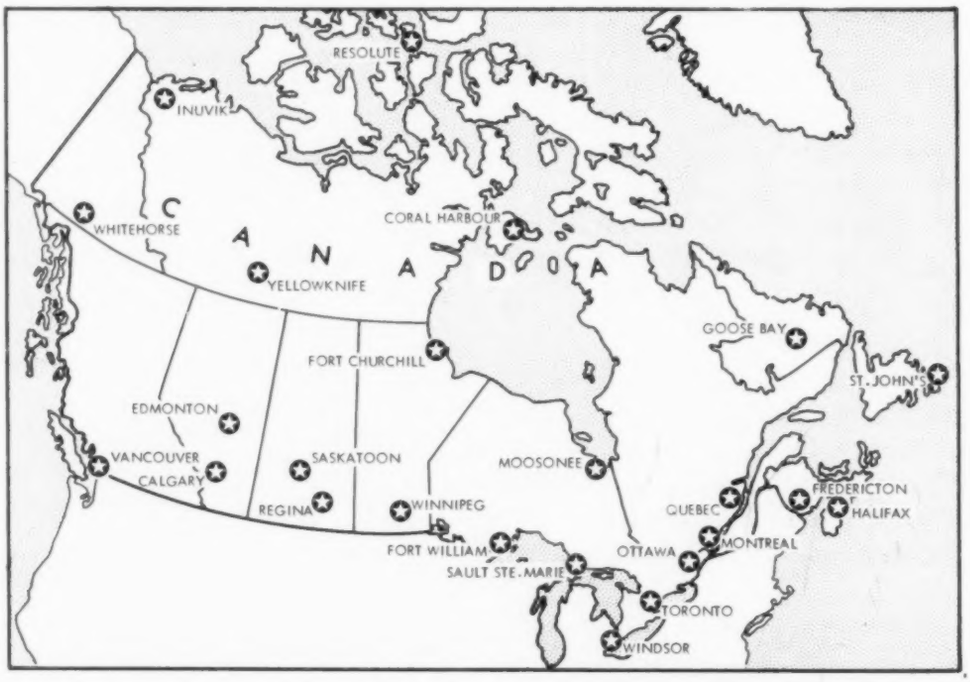

FIGURE 2.—CANADIAN AIR AND PRECIPITATION STATIONS, FEBRUARY 1964

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450° C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for February 1964 samples are given in table 4. Radionuclide analyses appear quarterly.

TABLE 4.—GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, FEBRUARY 1964

Station	Total beta activity	
	pc/liter	mc/m²
Calgary	[a]	7.3
Coral Harbour	916	20.9
Edmonton	789	8.4
Ft. Churchill	413	4.1
Ft. William	418	4.2
Fredericton	165	16.1
Goose Bay	124	10.9
Halifax	299	55.5
Inuvik	402	6.4
Montreal	346	10.8
Moosonee	254	9.3
Ottawa	232	7.3
Quebec	591	29.0
Regina	432	7.0
Resolute	432	18.6
St. John's, Nfld	432	38.7
Saskatoon	385	4.9
Sault Ste. Marie	411	12.3
Toronto	421	11.2
Vancouver	642	45.2
Whitehorse	299	4.4
Windsor	876	17.8
Winnipeg	801	4.5
Yellowknife	328	4.8
Average	444	15.0

[a] Trace precipitation.

3. Mexican Air Monitoring Program February 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961. The network consists of 17 stations (see figure 3), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada. Staff members of the RPP operate the station at Mexico while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6- x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactive", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum and average fission product beta concentrations in surface air during February 1964 are presented in table 5. The data are also represented in the beta activity isogram map of North America, figure 4.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, FEBRUARY 1964

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Acapulco	17	4.8	1.4	2.5
Ciudad Juárez	19	6.4	0.7	1.8
Chihuahua	12	3.2	0.3	1.1
Ensenada	9	3.3	1.2	2.1
Guadalajara [a]	0	—	—	—
Guaymas [a]	0	—	—	—
La Paz	16	4.0	1.6	3.6
Matamoros [a]	0	—	—	—
Mazatlán [a]	0	—	—	—
Mérida	8	2.3	0.4	1.4
Mexico City	17	1.3	0.1	0.5
Nuevo Laredo [a]	3	2.3	1.0	—
San Luis Potosí	10	2.4	0.3	1.3
Tampico [a]	0	—	—	—
Torreón	15	3.5	0.3	1.8
Tuxtla Gutiérrez [a]	0	—	—	—
Veracruz [a]	0	—	—	—

[a] Temporarily shut down.

FIGURE 3.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

4. Pan American Air Sampling Program February 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of the Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The three air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Santiago, Chile is operated by the Occupational Health Service; in Lima, Peru by the Institute of Occupational Health; and in Caracas, Venezuela by the Venezuelan Institute for Scientific Investigations. The Caracas station began operation in November 1962 and the other two stations were started the following month.

The February 1964 air monitoring results from the three participating countries are given in table 6. The Caracas station is shown on the gross beta concentration isogram map (figure 4) and its February average, 0.73 pc/m^3 (after adjustment by the RSN intercalibration factor[5]), was used in estimating the position of the 0.5 pc/m^3 isogram.

TABLE 6.—GROSS BETA ACTIVITY IN AIR, FEBRUARY 1964

[Concentrations in pc/m^3]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Caracas, Venezuela	20	0.87	0.28	0.57
Lima, Peru	0	—	—	—
Santiago, Chile	15	0.12	<0.10	0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

[5] The RSN factor is 1.28.

Gross Beta Activity in Air, North America, February 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[6] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors include some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The intercalibration factors are, therefore, not the same as were previously used.

Figure 4 shows the February 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

[6] The January through December 1963 Isogram Maps were published in the May 1963 through April 1964 issues of *Radiological Health Data*.

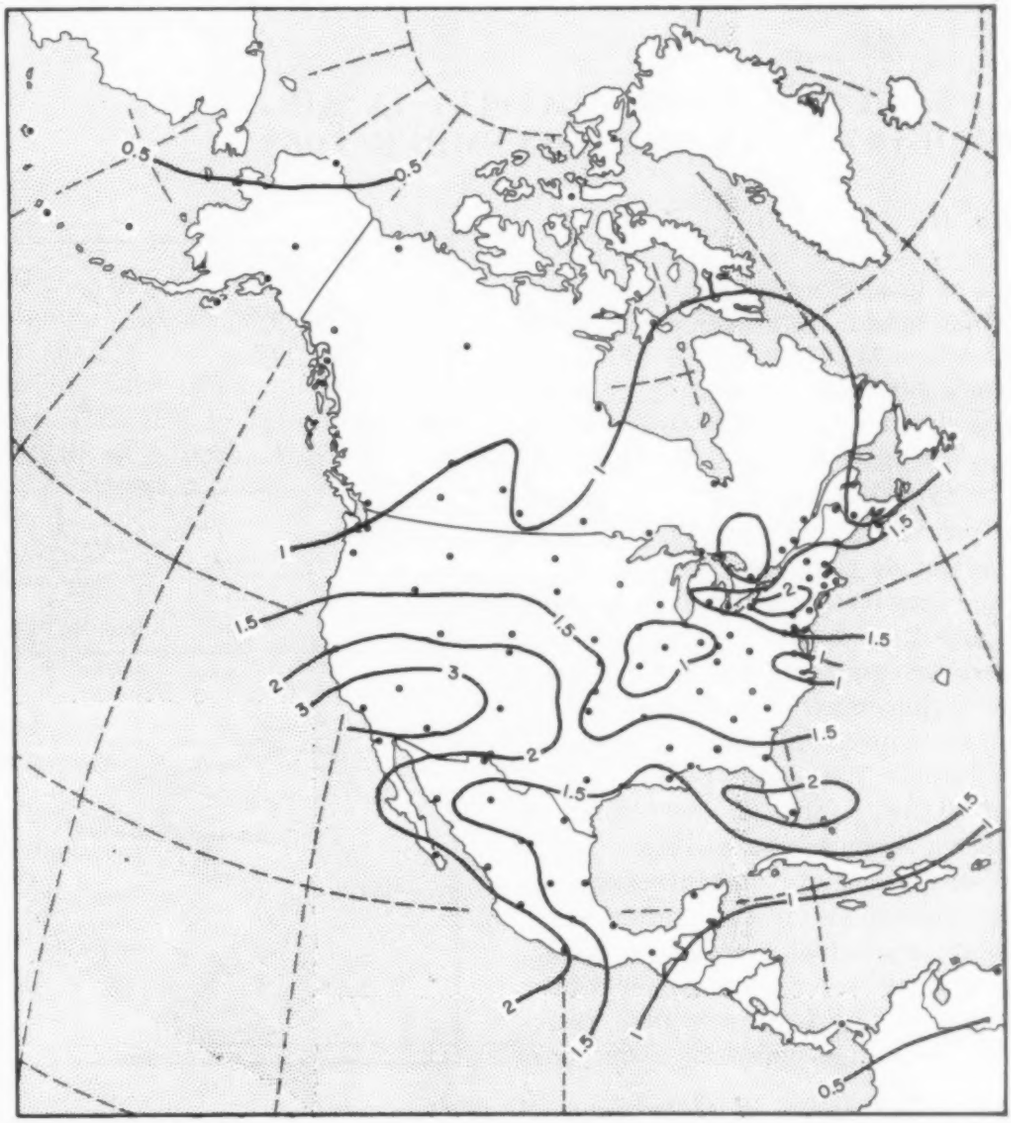

FIGURE 4.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR (pc/m³) THROUGHOUT NORTH AMERICA, FEBRUARY 1964

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FISSION PRODUCT GAMMA ACTIVITY IN AIR— 80TH MERIDIAN NETWORK, DECEMBER 1963

W. R. Collins, Jr.[1]

The results of total gamma activity measurements on ground level air filter samples taken at 80th Meridian stations (see figure 1) during December 1963 are listed in table 1, together with average monthly activities for each site and the ratios of photons with energies in excess of 1 Mev to total photon activity. Details of sampling procedure and analytical methodology have previously been described (*1, 2*).

The average activity concentrations are also plotted in figure 2 as an activity-latitude profile. The December results show slight decreases in air activity concentrations at most of the sites with a maximum of 1.2 γ/min/m^3 (gamma photons per minute per cubic meter) and a minimum of 0.018 γ/min/m^3 occurring at Miami and Punta Arenas, respectively.

Average monthly activity concentrations for the two hemispheres are plotted in figure 3. From these data a gradual decrease in air activity concentrations in both hemispheres over the year is apparent. By December 1963, activity concentrations had dropped to about one-

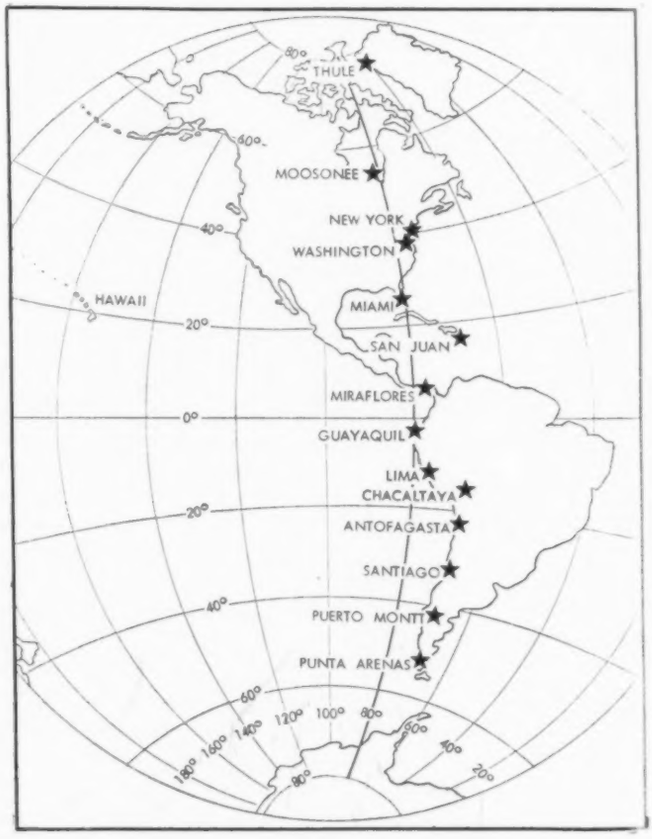

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

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TABLE 1.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, DECEMBER 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m³)		Gamma ratio $\left(\frac{\gamma>1\ \text{Mev}}{\text{total}\ \gamma}\right)$	Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m³)		Gamma ratio $\left(\frac{\gamma>1\ \text{Mev}}{\text{total}\ \gamma}\right)$
		Filter	Average for month				Filter	Average for month	
Thule, Greenland	1–8	0.814		0.055	Guayaquil, Ecuador	1–8	0.0367		0.056
	8–15	0.718		0.056		8–15	0.0688		0.073
	15–22	1.17		0.056		15–22	0.0556		0.079
	22–1/1	0.899	0.900	0.037		22–1/1	0.0524	0.0534	0.061
Moosonee, Canada	1–8	0.604		0.059	Lima, Peru	1–8	0.126		0.060
	8–15	0.636		0.054		8–15	0.120		0.062
	15–22	0.448		0.064		15–22	0.121		0.054
	22–1/1	0.423	0.528	0.062		22–1/1	0.104	0.118	0.062
New York, New York	1–8	0.795		0.069	Chacaltaya, Bolivia	1–8	0.0177		0.025
	8–15	0.478		0.065		8–15	0.0187		0.052
	22–1/1	0.656	0.643	0.065		15–22	0.0326		0.046
						22–1/1	0.0598	0.0322	0.060
Washington, D. C.	1–8	0.567		0.067					
	8–15	0.305		0.074	Antofagasta, Chile	1–8	0.0704		0.060
	15–22	0.553		0.065		8–15	0.0641		0.055
	22–1/1	0.602	0.507	0.063		15–22	0.0790		0.075
						22–1/1	0.0786	0.0730	0.061
Miami, Florida	1–8	1.58		0.057					
	8–15	1.39		0.063	Santiago, Chile	1–8	0.0911		0.074
	15–22	1.23		0.065		8–15	0.0641		0.076
	22–1/1	0.728	1.23	0.068		15–22	0.0790		0.080
						22–1/1	0.0786	0.0745	0.074
Mauna Loa, Hawaii	1–8	0.339		0.077					
	8–15	0.523		0.065	Puerto Montt, Chile	1–8	0.0460		0.067
	15–22	0.252		0.052		8–15	0.0391		0.078
	22–1/1	0.377	0.373	0.064		22–1/1	0.0416	0.0422	0.045
San Juan, Puerto Rico	1–8	0.390		0.061	Punta Arenas, Chile	1–8	0.0195		0.115
	8–15	0.334		0.049		8–15	0.0128		0.044
	15–22	0.348		0.058		22–1/1	0.0201	0.0175	0.053
	22–1/1	0.205	0.319	0.060					
Miraflores, Canal Zone	1–8	0.253		0.052					
	8–15	0.173		0.052					
	15–22	0.338		0.065					
	22–1/1	0.233	0.249	0.067					

tenth of the January levels, with averages of 0.73 γ/min/m³ and 0.062 γ/min/m³ in the Northern and Southern Hemisphere, respectively. During the year the greatest differences in the hemispheric averages occurred during April and May, when the spring maximum in the Northern Hemisphere coincided with the fall minimum in the Southern Hemisphere and the smallest divergences were in September and October when the seasonal effects were reversed.

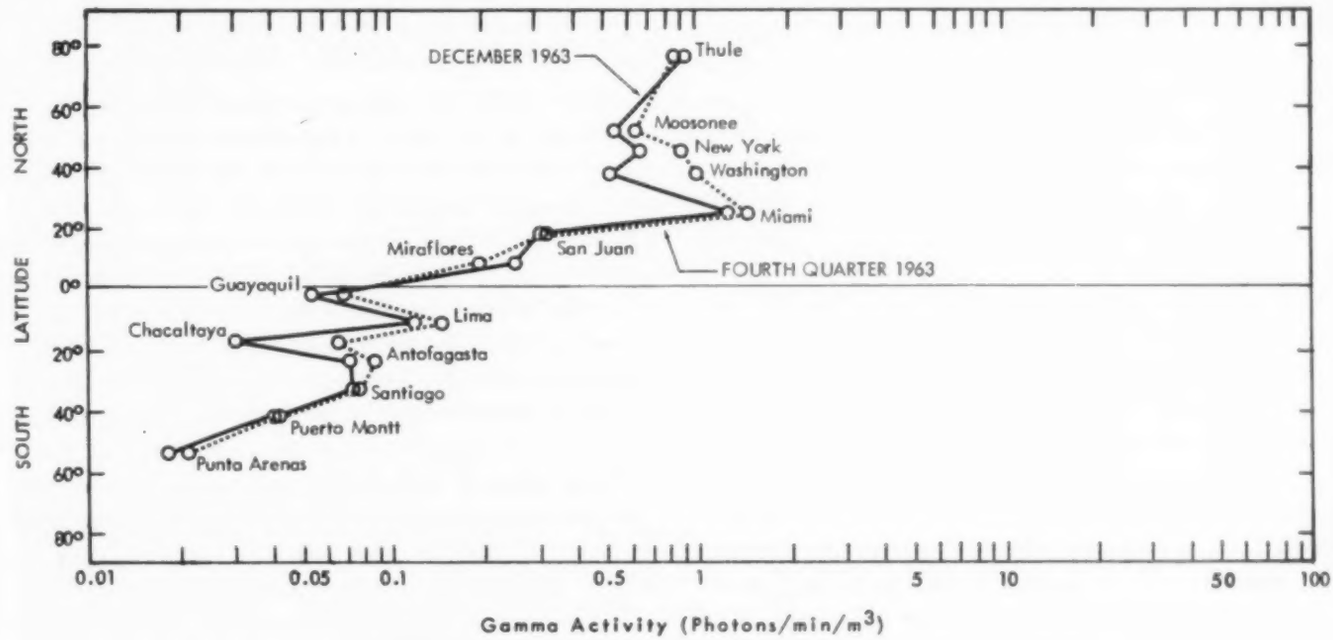

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, FOURTH QUARTER AND DECEMBER 1963

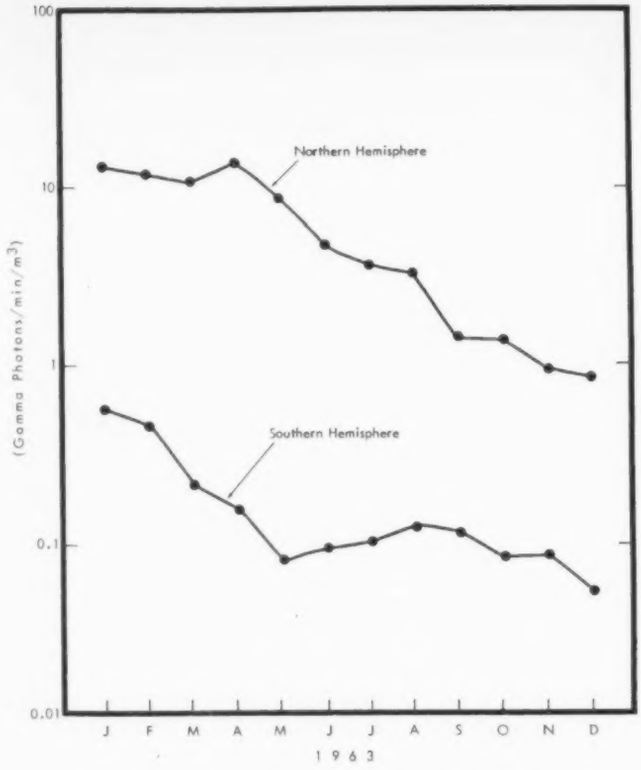

FIGURE 3.—AVERAGE MONTHLY GAMMA ACTIVITY IN GROUND LEVEL AIR DURING 1963

Use of the Photon Ratio

Since January 1963 the ratio of photons with energies in excess of 1 Mev to total photon activity has been measured routinely in the 80th Meridian samples as a means of detecting the presence of fresh debris. The method was based on experiments conducted at the Health and Safety Laboratory which showed that in fission products produced by thermal neutron irradiation of enriched uranium, the fraction of photons with energies in excess of 1 Mev decreased rapidly from about 0.2 to 0.01 during the first 5 months after irradiation and then did not vary from the latter value for at least another 10 months (*1*). These results were presented in the January 1963 80th Meridian Report and are updated in curve A of figure 4. From this plot it would be expected that samples having ratios higher than 0.01 would contain some proportion of fresh debris.

This change in ratio apparently does not hold for actual samples of thermonuclear weapons fallout. For example, the ratios for the December 80th Meridian sample listed in table 1 average 0.060 and 0.063 for the Northern and Southern Hemispheres, respectively. These values are consistent with the gradual increase in the ratios that has been noted in 80th Meridian samples since the spring of the year. This is shown in figure 4, where average monthly ratios for the year are plotted for comparison with the theoretical ratios. A mean production date of October 8, 1962, has been assumed for the fission products. It is apparent that the ratios are generally higher than would be predicted by the results of the thermal irradiation experiment (curve A in figure 4). This would still be true even if all the activity were attributed to the last known test in 1962.

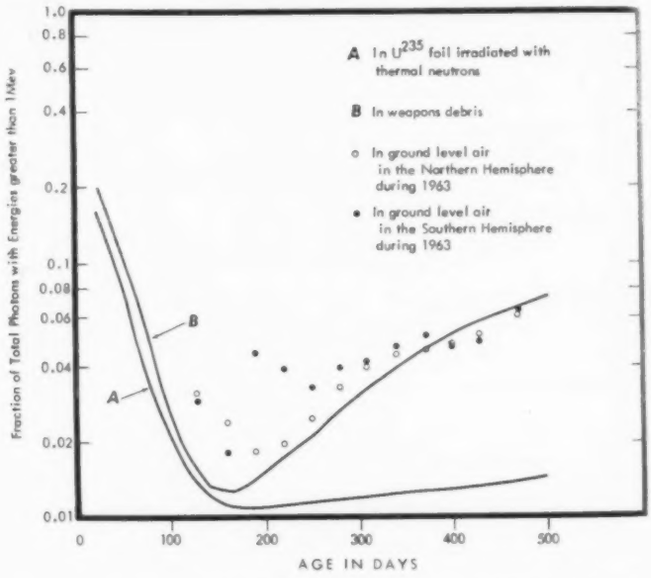

FIGURE 4.—FRACTIONS OF TOTAL GAMMA PHOTONS WITH ENERGIES IN EXCESS OF 1 MEV IN THEORETICAL AND ACTUAL FISSION PRODUCT SAMPLES AS A FUNCTION OF AGE

According to weapons yield data listed by Hallden *et al.*, (*3*), from 4.9 to 6.4 times more Ru^{106} atoms are produced by thermonuclear detonations than by thermal neutron fission. The Ru^{106}–Rh^{106} pair emits gamma radiation above 1 Mev and the possibility exists that this nuclide might be affecting the greater-than-1-Mev to total photon ratio found in the 80th Meridian samples. This was investigated by correcting the thermal fission data (illustrated in curve A of figure 4) for the deficiency in Ru^{106}. The results of these calculations are illustrated in curve B. The two curves are similar for fresh material, but as the relative contribution of Ru^{106} to total activity increases, curve B increases much more sharply than curve A. The validity of this estimate will be known when the radiochemical data become available.

Conclusions

The high ratios obtained for the April and May 80th Meridian samples were attributed in part to the presence of Sb^{124} (*4*). In addition, there is evidence that Y^{88}, Mn^{54}, Fe^{59}, and other activation products may have elevated or depressed the ratios from the expected values. Further information on this subject must also await the results of radiochemical analysis. However, despite the possible influences of activation products, it is apparent from figure 4 that the measured ratios for the 1963 80th Meridian samples conform more closely to the weapons debris curve B than to the thermal irradiation curve A.

Since curve B would indicate that both fresh and aged debris could yield high ratios, future detection of fresh debris in 80th Meridian samples must be based on month-to-month changes in the ratio, increases in total activity levels and gamma spectrometric identification of Ba^{140} or other short-lived nuclides in the samples. The photon energy ratio will therefore no longer be routinely reported.

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SUMMARY REPORT ON AIRBORNE FISSION PRODUCTS ALONG THE 80TH MERIDIAN (WEST), 1957–1962[1]

L. B. Lockhart, Jr., R. L. Patterson, Jr., A. W. Saunders, Jr. and R. W. Black[2]

In early 1956, with the increasing concern about the spread of contamination from nuclear weapons tests and a rising interest in the use of airborne radioactivity as a tracer for atmospheric processes, representatives of the U.S. Naval Research Laboratory (NRL), the U.S. Atomic Energy Commission and the U.S. Weather Bureau considered the feasibility and desirability of establishing a network of stations along the 80th Meridian (West) for making measurements of atmospheric radioactivity. Such a program was put into operation in 1956 with partial financial support by the Division of Biology and Medicine, U.S. AEC, and with the cooperation of a number of agencies and organizations located in countries along or near the 80th Meridian.

This network was in continuous operation by NRL during the periods of the International Geophysical Year and International Geophysical Cooperation—1959 until its voluntary transfer to the Health and Safety Laboratory of the U.S. Atomic Energy Commission on January 1, 1963.

Operation of the NRL 80th Meridian Air Sampling Program took place during an interesting period of the atomic age and the development of nuclear weaponry. It covered the nearly three-year moratorium on nuclear testing as well as the episodes of intensive testing of high

[1] Partial financial support of this program has been provided by the Fallout Studies Branch, Division of Biology and Medicine, U.S. Atomic Energy Commission.

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yield devices both before and after the moratorium. Data collected during this program have helped substantiate a number of concepts regarding atmospheric mixing processes and residence times of radioactive particulate matter in the atmosphere.

This report summarizes measurements of both gross beta activity and Sr^{90} activity in the air at ground level along the 80th Meridian during the period 1957 through 1962. More detailed results and interpretations are given for the collections of radioactivity made in 1962.

Experimental Procedures

Representative samples of the radioactive aerosols dispersed in the lower atmosphere were collected at the various sites by drawing ground-level air through highly efficient cellulose-asbestos filters 8 inches in diameter at the rate of about 1200 cubic meters per day. Continuous sampling was done at each site but the schedule of filter changes varied from daily, during 1957 through 1959, to thrice-weekly during 1960, and once per week during 1961 and 1962. Samples were returned to NRL by air for assay for gross beta activity and for radiochemical analysis.

TABLE 1.—RADIOCHEMICAL ANALYSES OF BIMONTHLY COMPOSITE AIR-FILTER COLLECTIONS, 80TH MERIDIAN (WEST) SAMPLING PROGRAM, 1962

[Concentrations in pc/m ^{3}] [a]

Station	Sampling period		Gross beta	Ce^{141}	Sr^{89}	Y^{91}	Ce^{144}	Pm^{147}	Sr^{90}	Cs^{137}	Pb^{210}
	1962	Days sampled [b]									
Thule, Greenland (elevation 259 meters)	Jan-Feb	49	4.60	[c] 0.29	0.653	1.076	0.581	0.095	0.0167	0.0251	0.00112
	Mar-Apr	63	6.01	[d] *	0.540	0.923	0.878	0.135	0.0297	0.0477	0.00783
	May-June	56	2.93	*	0.190	0.311	0.518	0.100	0.0226	0.0380	0.00459
	July-Aug	63	1.80	*	0.071	0.120	0.331	0.084	0.0149	0.0274	0.00344
	Sept-Oct	63	1.57	[c] 0.26	0.108	0.181	0.203	0.068	0.0077	0.0126	0.00290
	Nov-Dec	60	3.63	[c] 0.36	0.423	0.563	0.385	0.104	0.0130	0.0190	0.00428
Moosonee, Canada (elevation 10 meters)	Jan-Feb	57	3.93	[c] 0.27	0.500	0.905	0.473	0.067	0.0134	0.0164	0.00698
	Mar-Apr	63	5.96	*	0.509	0.738	0.779	0.121	0.0264	0.0299	0.00860
	May-June	56	5.60	*	0.297	0.482	0.756	0.144	0.0327	0.0468	0.00585
	July-Aug	63	3.02	[c] 0.035	0.129	0.242	0.509	0.125	0.0231	0.0405	0.00165
	Sept-Oct	63	1.99	0.18	0.130	0.209	0.229	0.063	0.00904	0.0158	0.00500
	Nov-Dec	63	3.49	[c] 0.65	0.374	0.513	0.297	0.063	0.00941	0.0158	0.00936
Washington, D. C (elevation 82 meters)	Jan-Feb	63	6.71	[c] 1.15	0.837	1.539	0.729	0.111	0.0199	0.0392	0.00272
	Mar-Apr	63	7.11	*	0.653	0.994	1.013	0.154	0.0352	[f]—	0.00815
	May-June	56	6.62	[c] 0.60	0.403	0.635	1.040	0.279	0.0399	0.0671	0.0145
	July-Aug	56	4.73	[c] 0.23	0.220	0.391	0.842	0.221	0.0405	0.0644	0.00518
	Sept-Oct	63	4.50	[c] 0.14	0.382	0.459	0.455	0.117	0.0161	0.0280	0.0164
	Nov-Dec	63	6.62	[c] 0.48	0.693	0.905	0.500	0.122	0.0155	0.0256	0.0198
Miami, Florida (elevation 4 meters)	Jan-Feb	63	7.70	[c] 1.05	0.882	1.841	0.815	0.125	0.0235	0.0177	0.00221
	Mar-Apr	63	10.91	*	0.941	1.805	1.296	0.243	0.0495	0.0504	0.00266
	May-June	56	4.88	*	0.310	0.549	0.761	0.173	0.0329	0.0288	0.00545
	July-Aug	63	1.68	*	0.086	0.153	0.280	0.073	0.0111	0.0132	0.00431
	Sept-Oct	63	3.25	[c] 0.19	0.305	0.531	0.327	0.068	0.0109	0.0095	0.00473
	Nov-Dec	63	11.12	[c] 1.91	1.098	1.467	0.765	0.180	0.0257	0.0255	0.00342
Mauna Loa, Hawaii (elevation 3394 meters)	Jan-Feb	63	5.81	[c] 0.77	0.905	1.143	0.563	0.107	0.0220	0.0357	0.00258
	Mar-Apr	63	7.29	*	0.783	1.323	1.121	0.192	0.0393	0.0666	0.00846
	May-June	56	6.03	*	0.441	0.639	0.887	0.213	0.0366	0.0653	0.00716
	July-Aug	53	3.30	*	0.244	0.391	0.513	0.137	0.0195	0.0370	0.00756
	Sept-Oct	56	2.12	*	0.202	0.243	0.204	0.0491	0.00918	0.01305	0.00409
	Nov-Dec	54	5.67	[c] 1.02	0.738	0.891	0.477	0.117	0.0176	0.0257	0.00603
Santiago, Chile (elevation 520 meters)	Jan-Feb	48	0.07	[c] 0.0027	[c] 0.0026	[c] 0.0015	0.00576	0.0072	0.00321	0.00648	0.00698
	Mar-Apr	63	0.04	*	[c] 0.0007	[c] 0.0010	0.00318	0.0039	0.00162	0.00385	0.00738
	May-June	42	0.42	[c] 0.146	0.0522	0.0702	0.0286	0.0103	0.00158	0.00399	0.0172
	July-Aug	[g]	—	—	—	—	—	—	—	—	—
	Sept-Oct	49	0.32	[c] 0.041	0.0204	0.0354	0.0388	0.0138	0.00244	0.00471	0.00612
	Nov-Dec	56	0.38	[c] 0.045	0.0217	0.0386	0.0540	0.0164	0.00304	0.00635	0.00513
Puerto Montt, Chile (elevation 5 meters)	Jan-Feb	56	0.03	[c] 0.0036	[c] 0.0071	[c] 0.0012	0.00395	0.00468	0.00215	0.00365	0.00084
	Mar-Apr	56	0.03	[c] 0.0006	[c] 0.0009	[c] 0.0006	0.00331	0.00415	0.00215	0.00374	0.00166
	May-June	63	0.05	[c] 0.0113	0.0081	0.0078	0.00414	0.00320	0.00106	0.00158	0.00290
	July-Aug	63	0.14	[c] 0.0338	0.0183	0.0259	0.01616	0.00806	0.00138	0.00176	0.00294
	Sept-Oct	56	0.09	[c] 0.0131	0.0105	0.0172	0.01706	0.00599	0.00147	0.00172	0.00185
	Nov-Dec	49	0.19	[c] 0.0113	0.0131	0.0232	0.0333	0.00954	0.00232	0.00331	0.00108
Punta Arenas, Chile (elevation 3 meters)	Jan-Feb	48	0.03	[c] 0.0023	[c] 0.0002	[c] 0.0003	0.00218	0.00320	0.00141	0.00307	0.00130
	Mar-Apr	63	0.01	[c] 0.0004	[c] 0.0002	0.0003	0.00150	0.00203	0.00103	0.00248	0.00082
	May-June	56	0.03	[c] 0.0063	[c] 0.0038	0.0049	0.00269	0.00234	0.00066	0.00186	0.00162
	July-Aug	63	0.07	[c] 0.0111	[c] 0.0060	0.0104	0.00743	0.00385	0.00065	0.00163	0.00232
	Sept-Oct	49	0.08	[c] 0.0081	[c] 0.0061	0.0114	0.01215	0.00393	0.00086	0.00175	0.00112
	Nov-Dec	56	0.08	[c] 0.0003	[c] 0.0057	0.0073	0.01148	0.00411	0.00087	0.00192	0.00059

[a] Counting error <2 percent (σ) unless otherwise indicated.
[b] Samples collected weekly but grouped by months.
[c] Indicates counting error >10 percent (σ).
[d] * indicates activity too low for measurement at time of analsyis.
[e] Indicates counting error in range of 2–10 percent (σ).
[f] Dash indicates no analytical results reported.
[g] Insufficient samples received.

Radiochemical analyses were carried out by standardized techniques on composited samples from each site covering monthly (alternate months during 1959–1960) or bimonthly periods (1961–1962). This information has been reported in detail elsewhere (*1–9*). The results of the 1962 radiochemical analyses are presented in table 1 in units of picocuries per cubic meter of standard air corrected to the midpoint of the collection period. Some of the activity ratios of current interest are listed in table 2.

Gross Fission Products In the Air

Linear plots of the average gross beta activity versus time in months from 1957 through 1962 are presented in figure 1 for each of the currently operated 80th Meridian air sampling stations. Association of periods of high activity with periods of nuclear testing and with spring subsidence of radioactivity from the stratosphere is evident. It is apparent that during the 1959–1961 moratorium on nuclear testing a quite considerable decrease in the fission product component of the atmospheric radioactivity took place. The linear plots, however, do not permit much detail to be observed during periods of low activity.

The change in radioactivity with time at corresponding Northern and Southern Hemisphere sites (Miami and Antofagasta) is shown in figure 2 on a semi-log scale for the 1958–1962 period. The strong seasonal effect on the stratospheric deposition rate is apparent at Miami during 1960 and 1961 but less obvious at Antofagasta. Conclusions derived from the 1962 radiochemical data do not permit this lack of a well-defined seasonal effect in the Southern Hemisphere during past years to be attributed to the equatorial crossover of debris during the Northern Hemisphere spring maximum. It is suggested instead that the unsymmetrical distribution of stratospheric debris with only a small Antarctic component in a position to enter the troposphere in the spring could be responsible. This lack of symmetry could also account for the considerably lower activity at the southernmost sites in Chile relative to activities at comparable latitudes in the Northern Hemisphere or to those at lower latitudes in the Southern Hemisphere.

Strontium-90 In the Air At Ground Level

The concentrations of Sr^{90} that have been encountered in the ground-level air at a number of sites near the 80th Meridian during the course of this study are plotted on a logarithmic scale in figure 3.

There has been a definite spring maximum in the Northern Hemisphere every year regardless of the past history of nuclear testing. The timing of nuclear tests prevented an unequivocable assignment of these changes to changes in the stratospheric deposition rate until the moratorium on testing showed conclusively that such a seasonal pattern did exist. The seasonal cycle has its highest amplitude in the subtropical latitudes (e. g. Miami) and least in the arctic region; moreover, the time of arrival of the radioactivity maximum varies with the latitude, arriving earliest in the more southerly regions.

In the Southern Hemisphere the same pattern of behavior appeared to exist but it was not so well defined—perhaps, as hypothesized above, the results of a different spacial distribution of the stratospheric source.

The imbalance in the stratospheric inventories of Sr^{90} activity over the two hemispheres at the conclusion of nuclear testing in December 1962 was even greater than existed at the close of 1958. The pattern of behavior expected for the Sr^{90} concentrations in the ground level air is for the high levels reported in the Northern Hemisphere during 1963 to be followed by a marked reduction in the spring of 1964, with smaller changes thereafter. Some increases in the Sr^{90} concentration with time might be expected in the Southern Hemisphere for several years as the tropically-centered stratospheric source migrates or diffuses to a region where downward mixing into the troposphere is more effective. Moreover, there should then be a more evident seasonal cycle south of the Equator due to the larger amplitude of the seasonal effect of a stratospheric source over the mid-latitude or polar regions.

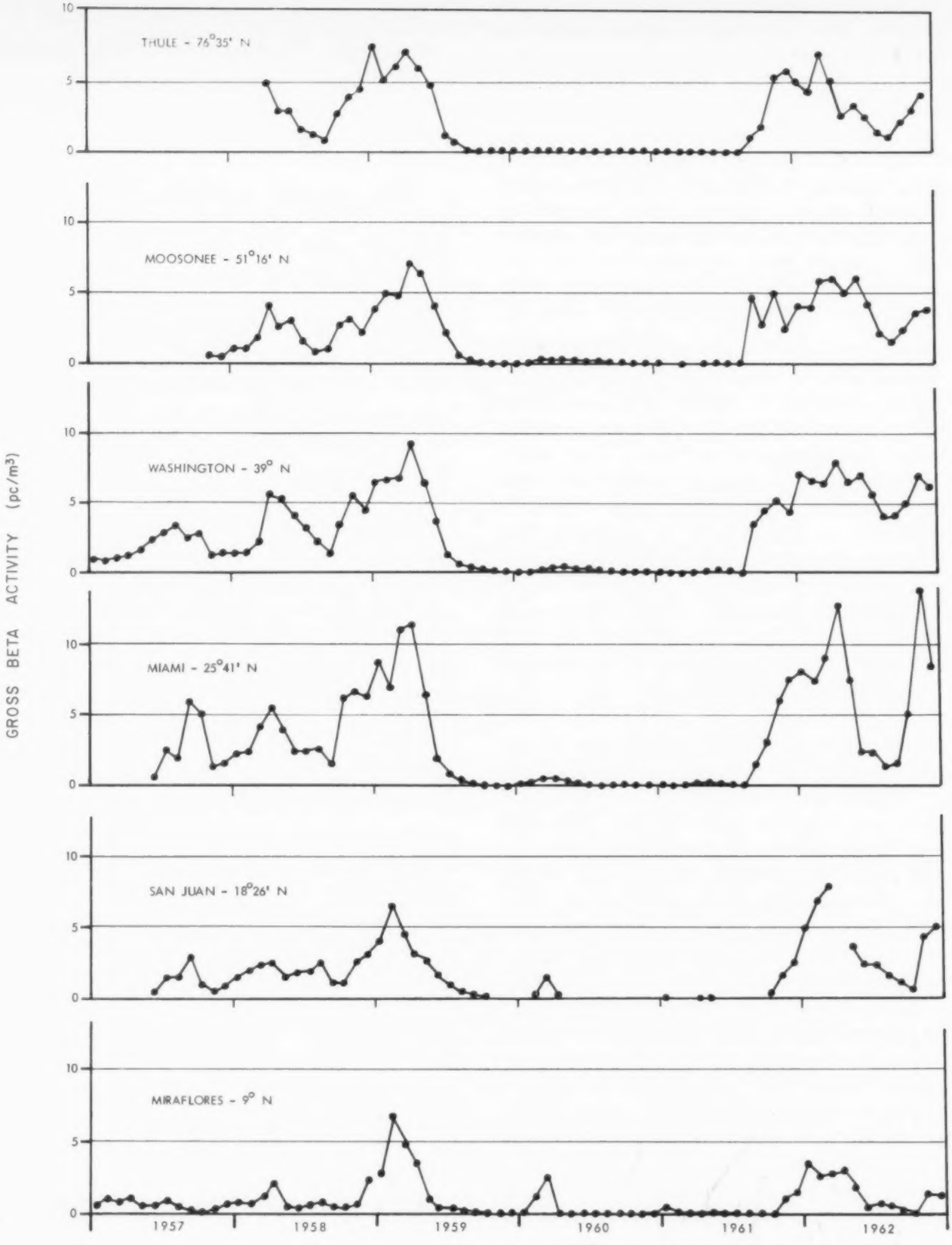
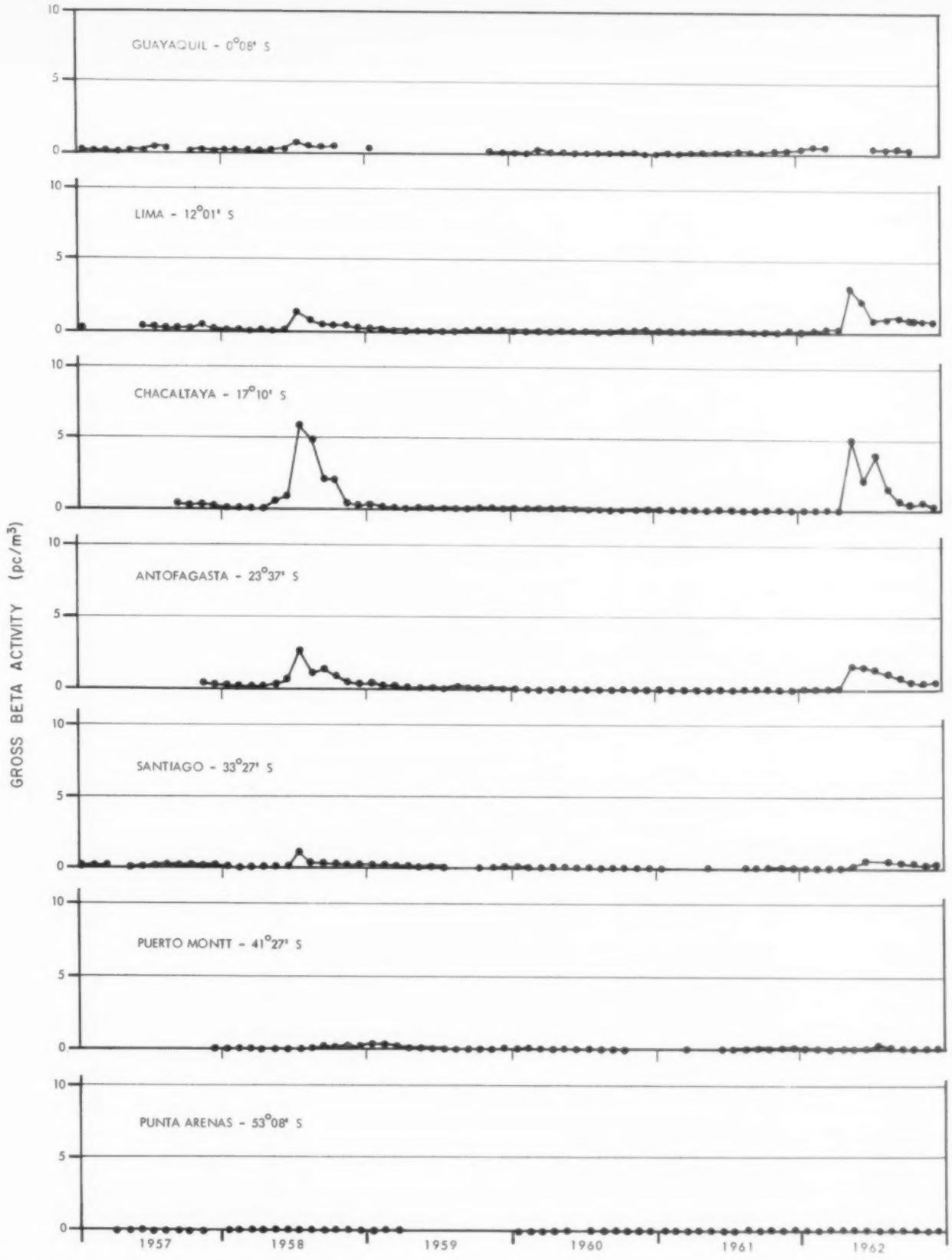


FIGURE 1.—FISSION PRODUCT BETA ACTIVITY IN AIR



ALONG THE 80TH MERIDIAN (WEST), 1957–1962

TABLE 2.—SELECTED RADIONUCLIDE ACTIVITY RATIOS, 80TH MERIDIAN SAMPLING PROGRAM, 1962

Station	Sampling period		[a] Ce^{141}/Ce^{144}	Sr^{89}/Sr^{90}	Y^{91}/Ce^{144}	Ce^{144}/Pm^{147}	Ce^{144}/Sr^{90}	Cs^{137}/Sr^{90}
	1962	Days sampled						
Thule, Greenland	Jan-Feb	49	0.5	39.1	1.35	6.1	34.8	1.90
	Mar-Apr	63	—	18.2	1.05	6.5	29.5	1.60
	May-June	56	—	8.4	0.60	5.2	22.9	1.68
	July-Aug	63	—	4.7	0.36	3.9	22.2	1.83
	Sept-Oct	63	1.3	14.0	0.89	3.0	26.4	1.63
	Nov-Dec	60	0.9	32.7	1.46	3.7	29.7	1.47
Moosonee, Canada	Jan-Feb	57	0.6	37.4	1.91	7.1	35.4	1.23
	Mar-Apr	63	—	19.3	0.95	6.4	29.5	1.13
	May-June	56	—	9.1	0.64	5.2	23.1	1.43
	July-Aug	63	0.07	5.6	0.48	4.1	22.0	1.75
	Sept-Oct	63	0.8	14.3	0.91	3.6	25.3	1.75
	Nov-Dec	63	2.2	39.8	1.73	4.7	31.6	1.68
Washington, D. C	Jan-Feb	63	1.6	42.0	2.11	6.6	36.6	1.96
	Mar-Apr	63	—	18.5	0.98	6.6	28.7	—
	May-June	56	0.6	10.1	0.61	3.7	26.1	1.68
	July-Aug	56	0.3	5.4	0.46	3.8	20.8	1.59
	Sept-Oct	63	0.3	23.7	1.01	3.9	28.2	1.74
	Nov-Dec	63	1.0	44.6	1.81	4.1	32.2	1.65
Miami, Florida	Jan-Feb	63	1.3	37.5	2.26	6.5	34.7	0.75
	Mar-Apr	63	—	19.0	1.39	5.3	26.2	1.02
	May-June	56	—	9.4	0.72	4.4	23.1	0.87
	July-Aug	63	—	7.7	0.55	3.8	25.2	1.19
	Sept-Oct	63	0.6	27.9	1.62	4.8	29.9	0.86
	Nov-Dec	63	2.5	42.7	1.92	4.2	29.8	0.99
Mauna Loa, Hawaii	Jan-Feb	63	1.4	41.2	2.03	5.3	25.6	1.63
	Mar-Apr	63	—	19.9	1.18	5.8	28.5	1.70
	May-June	56	—	12.1	0.72	4.2	24.2	1.78
	July-Aug	62	—	12.5	0.76	3.7	26.3	1.90
	Sept-Oct	60	—	22.0	1.19	4.2	22.3	1.42
	Nov-Dec	63	2.1	42.1	1.87	4.1	27.2	1.46
Miraflores, Panama Canal Zone	Jan-Feb	63	—	39.4	1.77	6.1	35.8	1.13
	Mar-Apr	63	—	18.9	1.01	6.2	29.5	1.19
	May-June	56	—	15.9	0.77	3.9	24.7	1.53
	July-Aug	62	—	10.8	0.65	5.0	28.9	1.94
	Sept-Oct	60	0.4	23.2	1.01	3.5	28.0	1.72
	Nov-Dec	63	0.9	47.3	1.73	3.2	33.5	1.50
Guayaquil, Ecuador	Jan-Feb	56	1.8	28.3	1.52	3.3	23.4	2.45
	Mar	35	0.6	18.0	1.05	3.0	21.2	2.41
	May-June[b]							
	Aug	39	1.6	29.5	1.31	3.1	41.0	2.00
	Sept-Oct	56	0.7	13.5	0.95	3.3	22.1	1.63
	Nov	21	2.5	12.0	0.93	3.3	19.8	1.80
Lima, Peru	Jan-Feb	55	0.6	3.5	1.00	1.6	4.3	2.46
	Mar-Apr	63	0.5	2.7	0.70	1.6	4.6	2.17
	May-June	63	5.0	70.1	2.40	5.8	38.1	1.74
	July-Aug	63	2.4	24.4	1.56	5.2	31.8	1.54
	Sept-Oct	56	0.6	11.8	0.92	3.8	23.7	1.43
	Nov-Dec	49	0.6	9.4	0.81	3.3	18.2	1.47
Chacaltaya, Bolivia	Jan-Feb	56	1.0	11.1	1.45	2.3	8.1	2.42
	Mar-Apr	59	0.4	—	0.69	1.6	—	—
	May-June	63	6.2	95.6	2.85	5.0	39.0	1.63
	July-Aug	42	1.7	39.6	1.45	5.1	52.3	1.44
	Sept-Oct	50	0.6	22.8	1.11	3.7	32.5	1.51
	Nov-Dec	63	0.6	12.9	0.81	3.0	22.8	1.58
Antofagasta, Chile	Jan-Feb	49	0.7	[a] 1.8	0.75	1.2	2.9	2.01
	Mar-Apr	60	0.5	[a] 1.9	0.68	1.4	3.6	2.42
	May-June	56	6.8	70.0	3.16	4.0	24.1	1.74
	July-Aug	63	1.5	22.4	1.58	4.4	29.5	1.61
	Sept-Oct	56	0.6	10.6	0.91	3.0	21.7	1.37
	Nov-Dec	63	0.5	8.3	0.75	2.9	18.7	1.58
Santiago, Chile	Jan-Feb	48	0.5	[a] 0.8	[a] 0.26	0.8	1.8	2.02
	Mar-Apr	63	—	[a] 0.4	[a] 0.33	0.8	2.0	2.37
	May-June	42	5.1	33.0	2.45	2.8	18.1	2.52
	July-Aug[b]							
	Sept-Oct	49	1.1	8.4	0.91	2.8	15.9	1.93
	Nov-Dec	56	0.8	7.1	0.71	3.3	17.8	2.09
Puerto Montt, Chile	Jan-Feb	56	0.9	[a] 3.3	[a] 0.31	0.8	1.8	1.70
	Mar-Apr	56	0.2	[a] 0.4	[a] 0.18	0.8	1.5	1.74
	May-June	63	2.7	7.6	1.88	1.3	3.9	1.49
	July-Aug	63	2.1	13.3	1.60	2.0	11.7	1.27
	Sept-Oct	56	0.8	7.1	1.01	2.8	11.6	1.17
	Nov-Dec	49	0.3	5.6	0.70	3.5	14.4	1.42
Punta Arenas, Chile	Jan-Feb	48	1.1	[a] 0.2	[a] 0.12	0.7	1.5	2.18
	Mar-Apr	63	0.2	[a] 0.2	[a] 0.19	0.7	1.5	2.41
	May-June	56	2.3	5.8	1.83	1.1	4.1	2.82
	July-Aug	63	1.5	9.2	1.39	1.9	11.4	2.50
	Sept-Oct	49	0.7	7.1	0.94	3.1	14.2	2.04
	Nov-Dec	56	0.2	6.5	0.64	2.8	13.1	2.20

[a] Value uncertain—error exceeds 10 percent.
[b] Insufficient samples received.

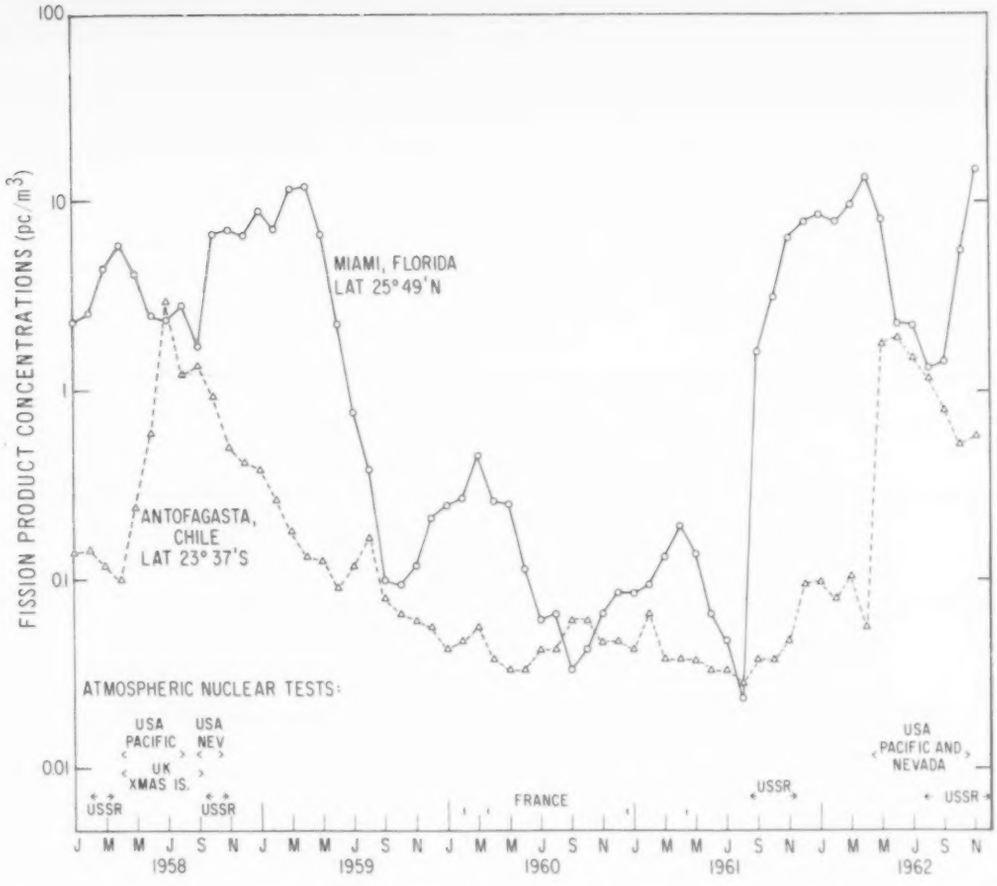


FIGURE 2.—MONTHLY AVERAGE CONCENTRATIONS OF GROSS FISSION PRODUCTS IN THE AIR AT MIAMI, FLORIDA, AND ANTOFAGASTA, CHILE, 1958–1962

Sources of Airborne Radioactivity During 1962

Consideration of the relative amounts of the different fission products in the air, particularly the Y^{91}, Ce^{144} and Sr^{90} activities, permitted approximate assignments of effective shot dates and contributions of Sr^{90} from the various sources to be made. This procedure is described in detail elsewhere (*9*).

In the Southern Hemisphere, the primary source of fission products prior to the end of April 1962 was pre-moratorium debris which had been retained in the stratosphere and slowly released. The relative contribution of Sr^{90} from the USSR 1961 tests was highest at Guayaquil (about 60%) and Chacaltaya (<20% but decreased to negligible quantities in southern Chile. The profiles of Sr^{90} assigned to the two sources during the January-February collection period are depicted in figure 4a. The suggested mechanism by which the fresher component was transferred to the Southern Hemisphere from the large source in the Northern Hemisphere is by the limited exchange of tropospheric air masses near the Equator, followed by entrainment of the transferred air in a rising cell which descended to ground level in the subtropical region of the Southern Hemisphere. The large quantity of Sr^{90} in the Northern Hemisphere is attributed primarily to the stratospheric deposition of debris from the USSR 1961 tests with about a 15 percent contribution of Sr^{90} from pre-moratorium tests.

After April 1962 a prominent contributor to radioactivity in the Southern Hemisphere was the U.S. test series at Christmas Island. As had been noted during the 1958 U.S. HARDTACK series, the fresh activity appeared in highest concentrations at Chacaltaya (elevation 5220 meters). In figure 4b the Sr^{90} profiles for the May-June period indicate the calculated contributions from each of the possible sources. No significant amounts of debris from the Christmas Island tests appeared in the Northern Hemisphere during this period.

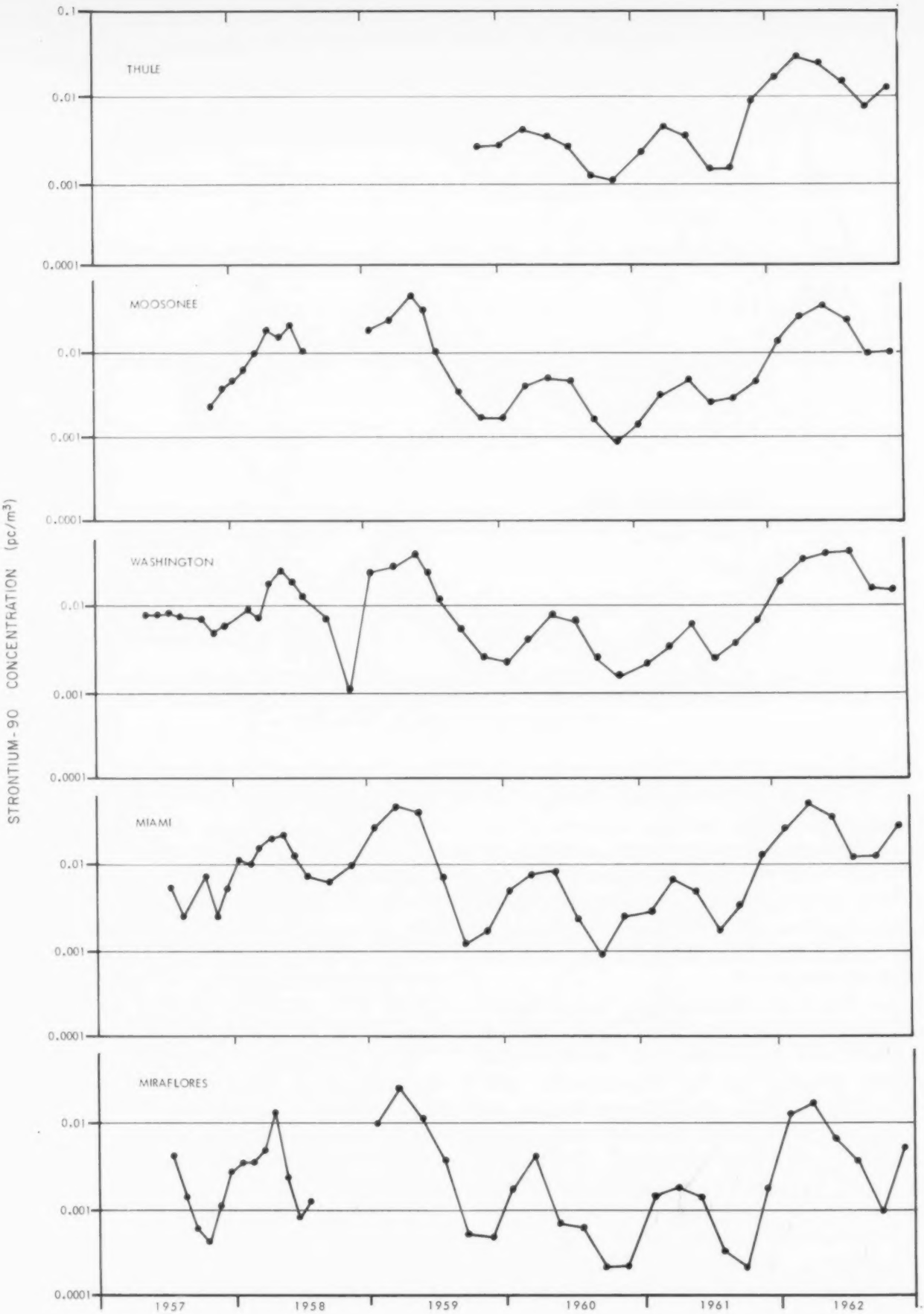
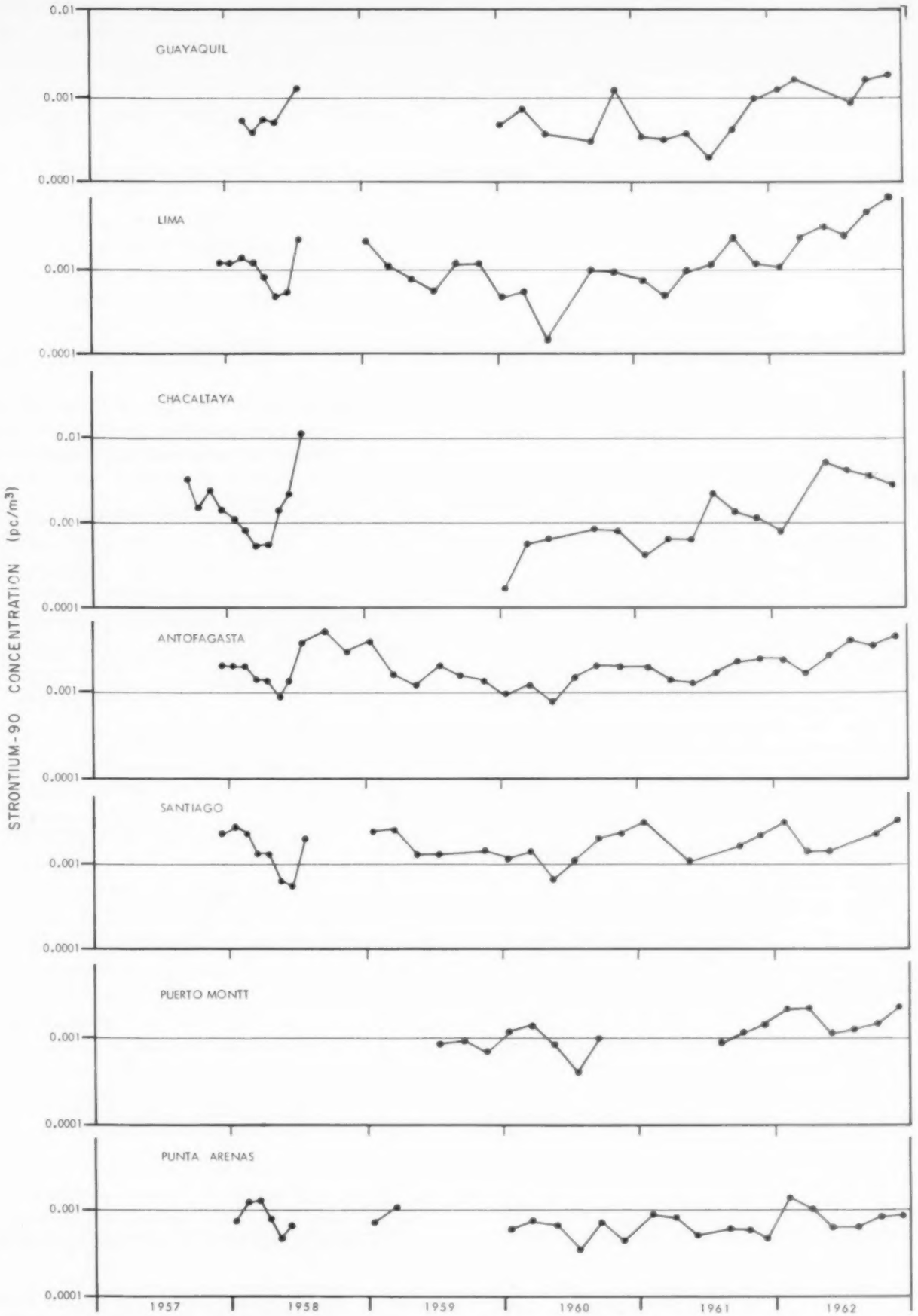


FIGURE 3.—CONCENTRATIONS OF STRONTIUM-90 IN THE AIR AT GROUND



LEVEL ALONG THE 80TH MERIDIAN (WEST), 1957–1962

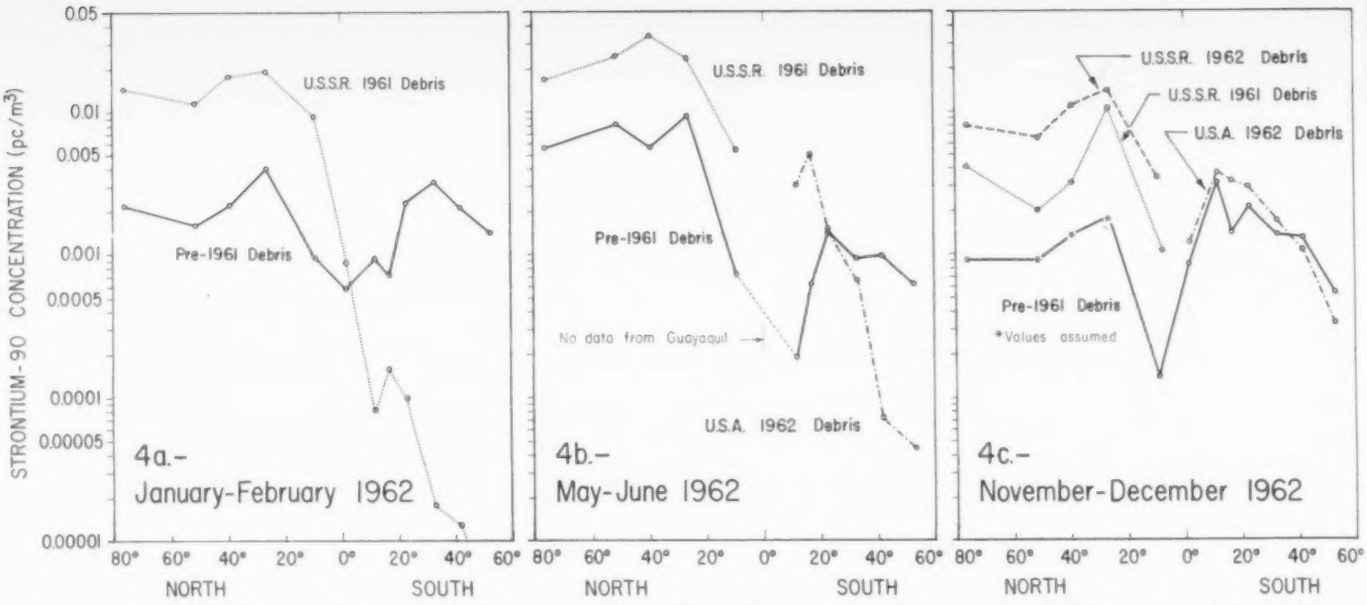


FIGURE 4.—PROFILES OF STRONTIUM-90 CONCENTRATIONS IN AIR ALONG THE 80TH MERIDIAN (WEST) DURING THREE PERIODS OF 1962 CONTRIBUTED BY VARIOUS NUCLEAR TEST SERIES

Throughout the remainder of 1962 the U.S. DOMINIC series appeared as the major source of Sr^{90} in the tropical and mid-latitudes of the Southern Hemisphere with smaller but gradually increasing contributions further south. By November-December 1962, when the Southern Hemisphere spring subsidence was bringing more stratospheric debris near the earth's surface, the old and new components were approximately equal.

The situation was more complex in the Northern Hemisphere. Though some DOMINIC debris did undoubtedly enter the Northern Hemisphere, it was not readily observable over the higher background of debris from the USSR 1961 series and, later, from the USSR 1962 series. The latitudinal profiles of Sr^{90} from the various sources for the November-December period are shown in figure 4c; here it has been assumed that the U.S. Christmas Island tests did not contribute to the Northern Hemisphere burden nor the USSR series to the Southern Hemisphere burden. An arbitrary estimate of the pre-moratorium Sr^{90} activity was also required.

Activity Ratios

The Sr^{89}/Sr^{90} activity ratios plotted in figure 5 compare the theoretical rate of change due to radioactive decay of debris from a megaton weapon detonated on October 15, 1961 (the effective mid-point of the USSR 1961 series), with measured ratios for the 80th Meridian air samples and for rainwater samples (*10, 11*) from several Northern Hemisphere sites. Scattered values during 1961 are due to mixed tropospheric and stratospheric sources of activity. The excellent agreement during early 1962, however, would indicate a common source of debris in collections made over a wide area.

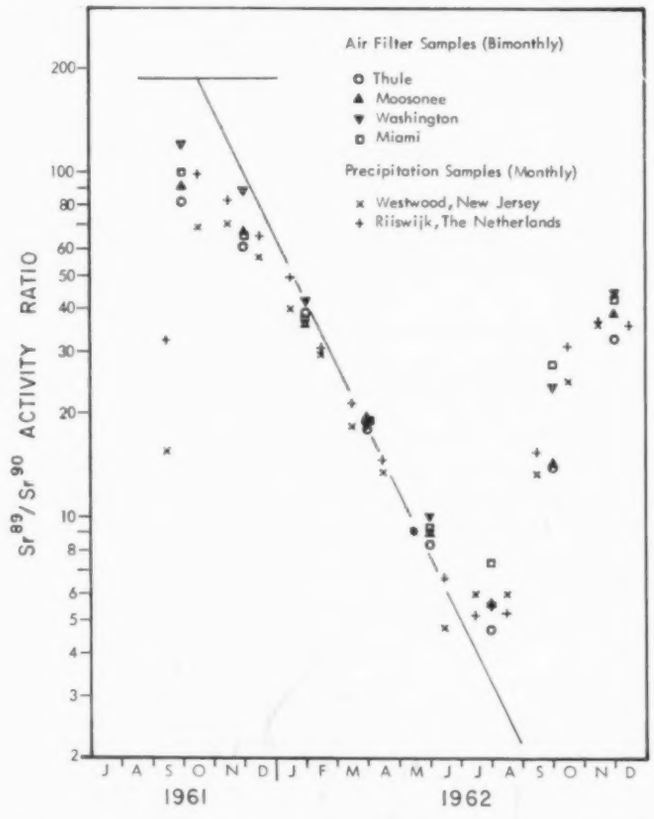


FIGURE 5.—RATIOS OF STRONTIUM-89 TO STRONTIUM-90 ACTIVITY IN THE AIR AND IN PRECIPITATION AT VARIOUS NORTHERN HEMISPHERE SITES DURING 1962

There is also evident at all sites a slowly decreasing age (increasing Sr^{89}/Sr^{90} ratio) which would suggest the gradual dilution of the source with younger debris, possibly from the extremely high yield USSR tests of October 23 and 30, 1961. Because of this, it is not possible to relate the slight increase in the Sr^{89}/Sr^{90} ratio found during May and June to the U.S. Christmas Island tests which started on April 25, 1962. However, rainfall collections made at Westwood, N.J. in May and June were reported to have contained Ba^{140} (12.8 day half-life) which indicated some contribution from the U.S. tests (*10*). The Sr^{89}/Sr^{90} activity ratio increased markedly later in the year as stratospheric deposition approached a minimum and large scale testing was resumed in the Soviet Union (August 5-December 24, 1962).

The Cs^{137}/Sr^{90} activity ratios have a rather high variability that cannot be related to any analytical difficulties and perhaps may be due to fractionation effects during transport or collection. This same pattern of variability with consistently lower than average values at Miami and Puerto Montt has been observed in past years (*7, 8*). The difficulty appears to be with the Cs^{137}, since other activity ratios involving the Sr^{90} component are as a general rule internally consistent both in space and time.

Summary

This report documents the changes in the gross beta and the Sr^{90} activity concentrations that have occurred in the air at ground level along the 80th Meridian from 1957 through 1962. The data obtained from this 80th Meridian air sampling program have contributed to our knowledge of the retention and transport of radioactivity within the atmosphere, the rather effective barrier to mixing across the Equator, and the seasonal cycles in the appearance of stratospherically-stored debris at ground level.

With the conduct of full scale testing of large yield nuclear devices in both the arctic and tropic regions during 1962, followed by what is presumed will be a more permanent moratorium on nuclear testing, the condition of the stratosphere and prospects for observations during the coming years are equivalent to those existing in the period 1959–1961. The multiplicity of sources will again cause difficulty in making quantitative interpretations of atmospheric mixing or transport processes, though there should be ample radioactivity for many other interesting studies.

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, February 1964

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After gamma scanning, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing the results of a large number of analyses. The ± 2 standard deviations (2σ) about the measured concentration corresponds to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10%
Barium-140	0 to 100	±10	100 or greater	±10%
Cesium-137	0 to 100	±10	100 or greater	±10%
Strontium-89	0 to 50	±5	50 or greater	±10%
Strontium-90	0 to 20	±2	20 or greater	±10%

[a] Two standard deviations (2σ).

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations determined from the gamma spectrum (1.18×10^{-3}g K/pc K^{40}).

Data Presentation

Table 2 presents summaries of the analyses for February 1964 (January 26-February 2 1964). Although not shown in table 2, the iodine–131 and barium–140 monthly average concentrations in milk were less than 10 pc/liter. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used as the best approximation in calculating the monthly average. Beginning with October 1963 data, however, zero is used as the best approximation to a nondetectable concentration of iodine–131 or barium–140. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations versus radionuclide concentrations in milk, table 3 has been prepared using monthly averages shown in table 2.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from 15 selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of strontium–90 concentrations was given for each station.

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, FEBRUARY 1964 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in *RHD* (1964)
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	
Ala:	Montgomery	1.22	1.20	1.5	1.5	5	<5	21	24	85	105	June
Alaska:	Palmer	1.20	1.14	1.6	1.5	15	10	31	23	180	165	March
Ariz:	Phoenix	1.16	1.15	1.7	1.5	<5	<5	3	5	30	20	May
Ark:	Little Rock	1.20	1.22	1.5	1.6	10	<5	40	41	130	165	March
Calif:	Sacramento	1.22	1.23	1.6	1.6	<5	5	8	9	60	60	April
	San Francisco	1.22	1.21	1.6	1.6	5	5	9	13	70	75	June
Canal Zone:	Cristobal	1.13	1.14	1.5	1.6	<5	<5	5	6	40	50	March
Colo:	Denver	1.19	1.22	1.6	1.5	15	<5	17	19	85	95	April
Conn:	Hartford	1.19	1.16	1.6	1.6	10	<5	25	22	170	180	April
Del:	Wilmington	1.21	1.20	1.7	1.6	5	<5	23	19	130	150	May
D. C:	Washington	1.17	1.19	1.5	1.5	10	5	17	17	80	105	June
Fla:	Tampa	1.22	1.21	1.4	1.5	5	<5	16	16	250	190	May
Ga:	Atlanta	1.19	1.26	1.5	1.6	10	5	29	38	120	160	June
Hawaii:	Honolulu	1.15	1.20	1.7	1.6	10	<5	11	12	85	75	March
Idaho:	Idaho Falls	1.19	1.15	1.6	1.6	15	<5	26	39	170	240	May
Ill:	Chicago	1.18	1.18	1.7	1.6	10	<5	20	21	110	145	June
Ind:	Indianapolis	1.25	1.23	1.6	1.5	10	<5	22	24	100	115	April
Iowa:	Des Moines	1.18	1.20	1.5	1.5	15	<5	25	27	100	105	May
Kans:	Wichita	1.16	1.24	1.6	1.6	10	<5	18	24	65	80	March
Ky:	Louisville	1.16	1.20	1.5	1.6	15	<5	30	31	100	125	May
La:	New Orleans	1.24	1.22	1.5	1.5	15	5	44	49	135	155	March
Maine:	Portland	1.22	1.17	1.6	1.6	10	<5	35	32	235	215	May
Md:	Baltimore	1.14	1.19	1.4	1.5	10	<5	20	20	105	115	May
Mass:	Boston	1.22	1.20	1.6	1.6	15	<5	36	34	250	255	June
Mich:	Detroit	1.20	1.20	1.6	1.5	5	<5	20	19	120	130	April
	Grand Rapids	1.23	1.20	1.6	1.5	5	<5	22	23	130	140	May
Minn:	Minneapolis	1.18	1.16	1.6	1.6	25	5	33	38	155	190	June
Miss:	Jackson	1.25	1.26	1.4	1.5	15	10	36	38	105	125	April
Mo:	Kansas City	1.17	1.18	1.5	1.5	15	10	29	29	85	100	April
	St. Louis	1.20	1.18	1.6	1.5	15	<5	21	23	85	95	March
Mont:	Helena	1.20	1.18	1.6	1.5	10	<5	29	33	195	230	March
Nebr:	Omaha	1.20	1.18	1.6	1.6	25	5	25	26	95	105	May
Nev:	Las Vegas	1.14	1.21	1.7	1.5	<5	<5	10	14	80	85	June
N. H:	Manchester	1.24	1.19	1.6	1.7	10	<5	37	34	275	260	May
N. J:	Trenton	1.20	1.19	1.6	1.5	10	<5	19	17	120	135	April
N. Mex:	Albuquerque	1.16	1.18	1.6	1.5	<5	<5	11	14	50	55	March
N. Y:	Buffalo	1.18	1.16	1.7	1.6	10	<5	23	20	145	175	April
	New York	1.20	1.16	1.7	1.6	15	<5	30	26	175	185	June
	Syracuse	1.19	1.19	1.7	1.7	10	5	22	22	150	165	March
N. C:	Charlotte	1.19	1.25	1.5	1.5	15	5	30	28	105	115	March
N. Dak:	Minot	1.18	1.20	1.6	1.5	40	10	55	67	145	165	May
Ohio:	Cincinnati	1.23	1.22	1.6	1.5	10	<5	23	24	90	125	April
	Cleveland	1.22	1.21	1.7	1.6	5	<5	22	20	105	125	March
Okla:	Oklahoma City	1.17	1.21	1.5	1.6	5	<5	21	27	70	90	June
Ore:	Portland	1.21	1.22	1.6	1.5	20	5	30	26	180	145	April
Pa:	Philadelphia	1.22	1.19	1.6	1.6	5	<5	21	19	120	140	March
	Pittsburgh	1.27	1.19	1.6	1.6	10	<5	29	27	145	170	March
P. R:	San Juan	1.16	1.17	1.5	1.6	5	<5	12	12	65	70	March
R. I:	Providence	1.21	1.18	1.6	1.6	5	<5	27	24	175	190	May
S. C:	Charleston	1.21	1.21	1.5	1.5	10	<5	27	36	120	150	April
S. Dak:	Rapid City	1.20	1.15	1.7	1.5	25	5	42	45	170	170	June
Tenn:	Chattanooga	1.23	1.22	1.5	1.5	15	5	35	35	120	145	June
	Memphis	1.22	1.23	1.5	1.5	10	<5	28	32	75	80	May
Tex:	Austin	1.18	1.20	1.5	1.6	<5	<5	8	11	40	55	June
	Dallas	1.20	1.21	1.5	1.6	5	<5	19	21	75	90	April
Utah:	Salt Lake City	1.19	1.22	1.6	1.5	15	5	26	28	170	210	March
Vt:	Burlington	1.21	1.17	1.6	1.6	10	<5	28	28	200	205	April
Va:	Norfolk	1.17	1.19	1.5	1.5	10	<5	21	19	90	105	April
Wash:	Seattle	1.21	1.20	1.6	1.5	15	10	24	20	155	115	June
	Spokane	1.21	1.22	1.7	1.6	20	5	31	35	160	145	April
W. Va:	Charleston	1.17	1.22	1.4	1.5	15	<5	26	26	85	110	June
Wis:	Milwaukee	1.28	1.22	1.8	1.7	<5	<5	19	19	135	155	May
Wyo:	Laramie	1.18	1.11	1.6	1.5	15	5	20	24	115	105	May
Network average		1.20	1.20	1.6	1.6	11	<5	24.2	25.3	123	135	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

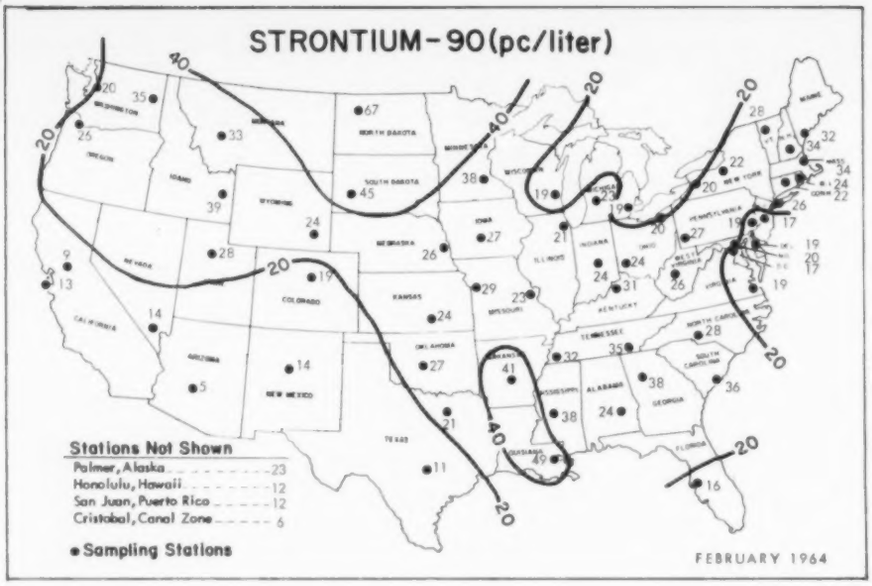


FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, FEBRUARY 1964

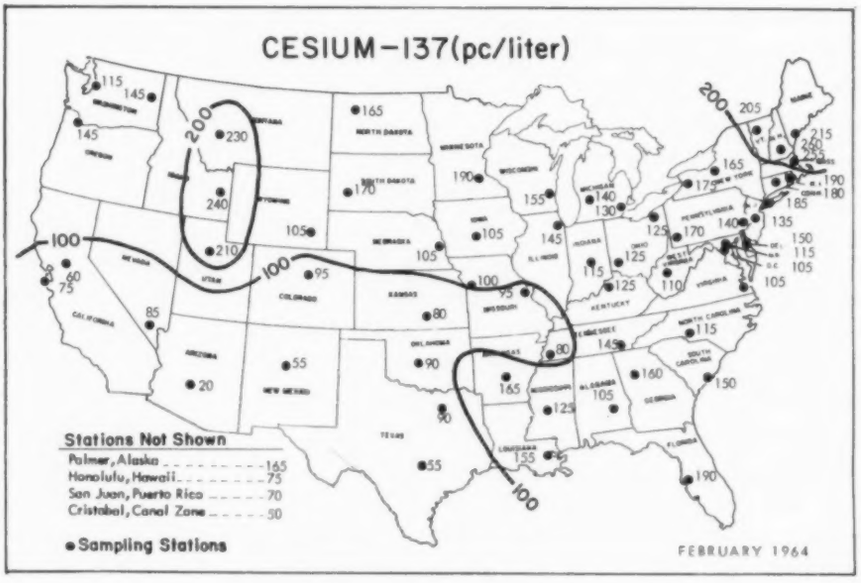


FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, FEBRUARY 1964

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, FEBRUARY 1964

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5	43	<1-9	3	<10	63	<5-45	1	<10	63
5	15	10-14	6			50-95	14		
10	5	15-19	9			100-145	24		
		20-24	17			150-195	17		
		25-29	11			200-245	5		
		30-34	6			250-295	2		
		35-39	7						
		40-69	4						
Total	63	Total	63	Total	63	Total	63	Total	63

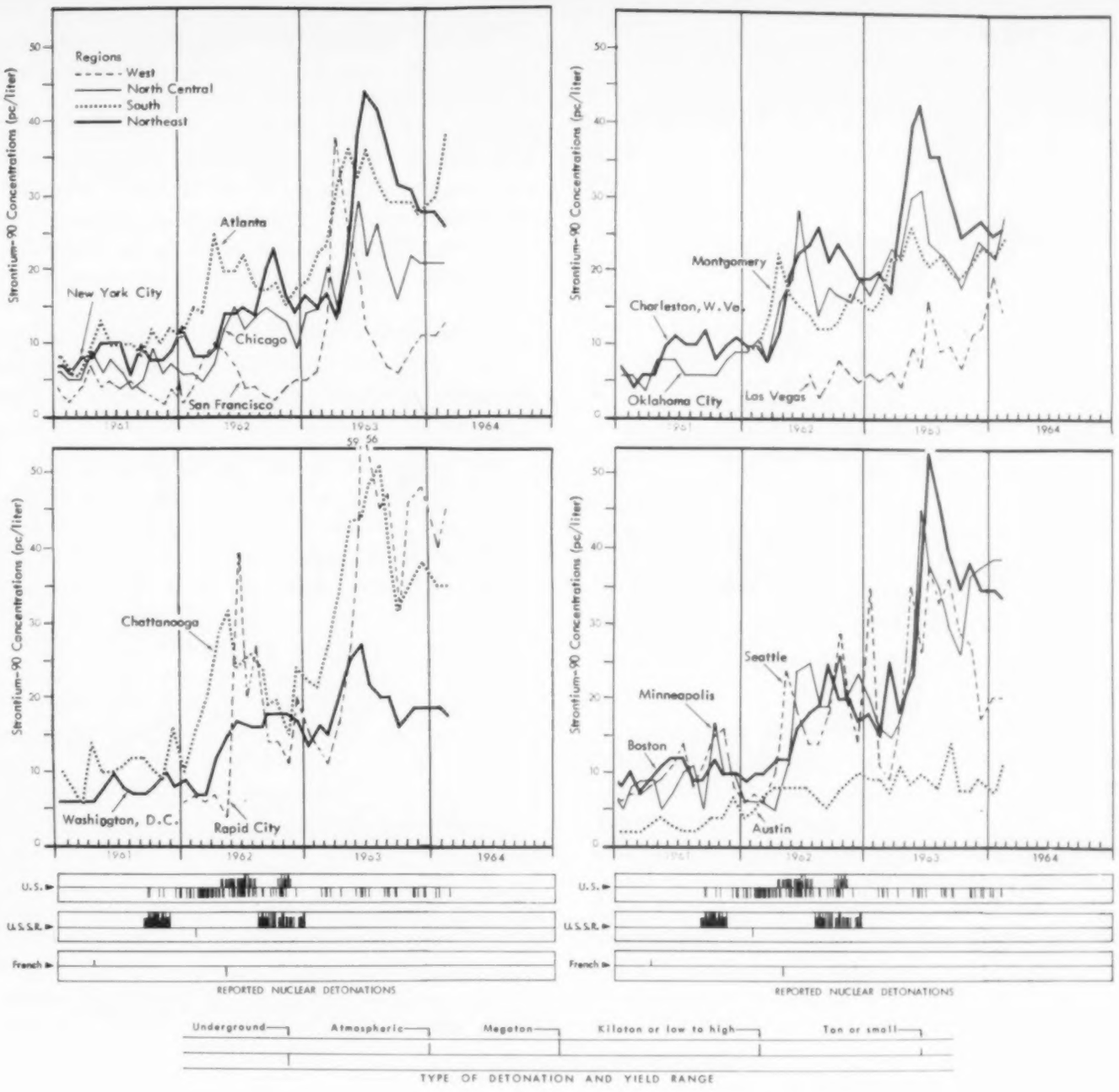


FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961—FEBRUARY 1964

2. California Milk Network,[2] October-December 1963

State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino milksheds to the program in March 1962, sampling of pasteurized milk weekly or biweekly has been conducted at 10 major milksheds (see figure 4). The original sampling locations were chosen by the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

[2] Data from *Radiological Health News* Vol. 3, No. 2, Bureau of Radiological Health, State of California Department of Public Health, 2151 Berkeley Way, Berkeley 4, California.

FIGURE 4.—CALIFORNIA MILKSHEDS

Methodology

Radiostrontium is determined by beta counting of strontium (yttrium) isolated from the filtrate obtained after precipitation of the proteins with trichloroacetic acid. The beta counting is done in a low background counter, usually for a 60-minute period.

Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma scintillation spectroscopy using a sodium-iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium–40 concentration (pc/liter) by 1.18 x 10^{-3}. A more complete description of the laboratory equipment and procedures has been published in the February 1963 issue of *Radiological Health Data* (*2*).

Results

The monthly averages of the radionuclide and calcium data for milk for the period October-December 1963 are presented in table 4. The

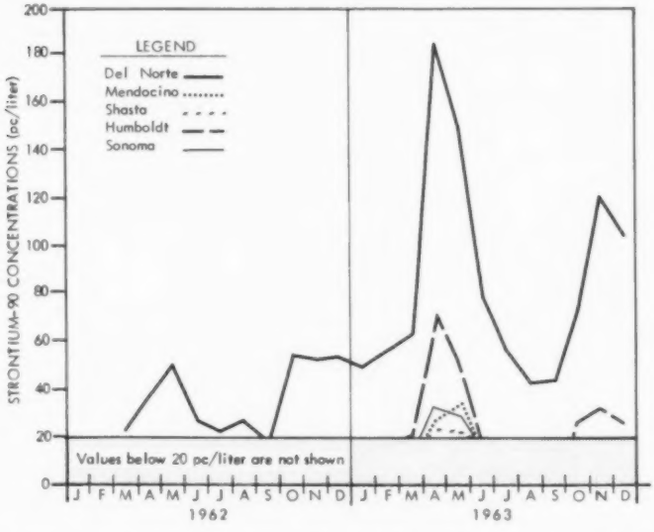


FIGURE 5.—MONTHLY AVERAGE STRONTIUM–90 CONCENTRATIONS IN MILK FROM ALL CALIFORNIA MILKSHEDS

TABLE 4.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN CALIFORNIA MILK, OCTOBER–DECEMBER 1963 [a]

[Radioactivity concentrations in pc/liter]

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
October	1.33	1.15	1.19	1.11	1.19	1.17	1.18	1.16	1.14	1.23	1.19
November	1.33	1.16	1.22	1.13	1.18	1.22	1.14	1.17	1.21	1.24	1.20
December	1.34	1.25	1.17	1.16	1.23	1.26	1.20	1.20	1.31	1.30	1.24
Potassium-40											
October	1140	1190	1150	1200	1220	1200	1230	1180	1200	1220	1190
November	1210	1180	1220	1270	1340	1290	1300	1290	1180	1300	1260
December	1150	1280	1200	1270	1280	1260	1300	1230	1280	1260	1250
Strontium-89											
October	83	4	27	3	5	6	2	2	4	7	14
November	102	5	29	3	8	8	3	4	9	6	18
December	28	3	16	4	5	4	2	4	9	7	8
Strontium-90											
October	73	4	27	4	6	6	3	3	5	6	14
November	121	6	33	7	10	8	5	5	12	11	22
December	104	6	27	5	9	6	4	9	14	9	19
Cesium-137											
October	277	41	111	49	47	41	27	44	55	49	74
November	467	64	165	59	54	70	54	57	84	73	115
December	339	60	104	57	61	59	53	97	114	81	103

[a] All values tabulated are at least twice the counting error at the 95 percent confidence level. The monthly iodine-131 and barium-140 averages at all stations during this period were zero.

monthly average concentrations of strontium–90 in milk for 1962–63 are shown in figure 5. Background information on the differences among the California milksheds were discussed by Heslep and Cornish in the December 1963 issue of *Radiological Health Data* (*3*).

3. Indiana Milk Network, February 1964

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 6).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station.

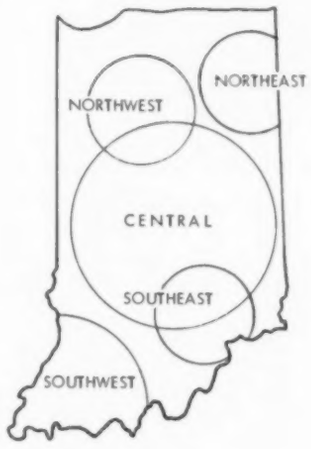


FIGURE 6.—INDIANA MILK SAMPLING LOCATIONS

An ion exchange analytical procedure (*4*) is employed for strontium–89 and strontium–90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium–140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 5. The State average is an arithmetic average of the station values.

TABLE 5.—CALCIUM AND RADIONUCLIDES IN INDIANA MILK, FEBRUARY 1964 [a]

[Radionuclide concentrations in pc/liter]

Sampling location	Calcium (g/liter)	K^{40}	Sr^{89}	Sr^{90}	Cs^{137}	Ba^{140}
Northeast	1.10	1260	0	13	115	0
Southeast	1.14	1280	0	21	120	0
Central	1.15	1280	0	14	115	0
Southwest	1.14	1200	0	15	110	10
Northwest	1.15	1310	5	15	125	0
State average	1.14	1270	0	16	115	0

[a] The monthly average iodine-131 concentration at each station was zero.

4. Minnesota Milk Network, July-December 1963

Division of Environmental Sanitation
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a surveillance network to monitor pasteurized milk for strontium–90. Through October 1962, the network operators collected daily two-ounce milk samples that were composited together for monthly strontium–90 analyses. Beginning in October 1961, weekly one-liter grab samples were also collected for iodine–131 analyses. Then, beginning in November 1962, a portion of each weekly sample was retained for monthly strontium–90 analyses.

In August 1963, the network began sampling for iodine–131, cesium–137 and strontium–90 analyses on the monthly sampling basis which is now in effect. At present the network consists of eight milksheds bounded by the same lines as the Minnesota health districts. One-liter samples of processed Grade A fluid milk samples are collected at bottling machines in the pasteurized plants so that samples are gen-

FIGURE 7.—MINNESOTA MILK SAMPLING LOCATIONS

erally representative of the milk produced in each milkshed. These samples are usually collected in the cities where the Minnesota Health District Office is located. It is sometimes convenient to collect a sample in a district at a location other than that in which the district office is situated. This type of sample is considered as representative of the district as a sample collected in the vicinity of the district office.

Analytical Procedure

Strontium–90 in milk is determined after ashing (450° C) the evaporated residue from an 800-ml sample. Evaporation is accomplished by means of a steam bath and infrared overhead heating. Calcium and strontium are precipitated as oxalates at a pH of 4 from a nitric acid solution of the ash. The separated oxalates are then decomposed with nitric acid and peroxide and the resulting solution scavenged with yttrium and barium (as chromate) in the presence of ammonium chloride. Yttrium–90 is allowed to ingrow in the presence of stable yttrium carrier and then precipitated under the same conditions prevailing in the scavenging procedure. The yttrium precipitate is converted to the oxalate, filtered and counted in a low-background anticoincidence counter.

Iodine–131 and cesium–137 are determined by gamma spectrometry. One-liter samples of milk are counted for 100 minutes with a low-background sodium iodide crystal scintillator and multichannel analyzer. Either a 3 x 3-inch crystal and 256-channel analyzer or a 4 x 4-inch crystal and 512-channel analyzer is used. The counts in the iodine–131 photopeak which occur because of background and scatter from other gamma-emitting nuclides in milk are subtracted from the total. The value to be subtracted is empirically determined, and is based on the slope of the spectrum in this area and the magnitude of the counts in the channels adjacent to the photopeak. The minimum detectable concentration of iodine–131 in milk is 10 pc/liter.

Results

The monthly strontium–90, iodine–131, and cesium–137 concentrations in milk are given in table 6. These data as well as analytical procedures are presented in the semiannual report of the Minnesota Department of Health and Rural Cooperative Power Association (*5*).

Recent coverage in *Radiological Health Data:*

Period	*Issue*
October-December 1961 (iodine–131 data)	*March 1962*
May-December 1961 (strontium–90 data)	*August 1962*
March-September 1962	*April 1963*
September 1962-June 1963	*November 1963*

TABLE 6.—RADIONUCLIDES IN MINNESOTA MILK, JULY–DECEMBER 1963 [a]

[Concentrations in pc/liter]

Sampling location (District office)	Strontium-90						Cesium-137					
	July	August	September	October	November	December	July	August	September	October	November	December
Bemidji	49	64	63	49	31	46	344	435	420	310	270	310
Duluth	54	38	48	43	40	47	378	410	340	[b] —	360	340
Fergus Falls	42	40	33	49	30	30	214	265	230	240	210	260
Little Falls	56	35	29	19	22	—	394	270	235	240	—	330
Mankato	28	26	19	20	19	22	184	200	170	—	180	190
Minneapolis	51	33	23	20	28	35	238	265	195	215	210	275
Rochester	29	30	25	28	38	25	186	210	160	—	190	220
Worthington	40	26	27	16	20	23	174	140	—	140	145	150
Average	43.6	36.5	33.4	30.5	28.5	32.6	245	275	253	226	224	249

[a] Each monthly iodine-131 concentration at each station was <10 pc/liter during July–December 1963.
[b] A dash indicates no sample.

5. New York Milk Network, October-December 1963

Division of Environmental Health Services, State of New York Department of Health

Milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 8)—are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, cesium–137 and barium–140–lanthanum–140 at all stations except Massena, where samples are composited bi-weekly and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once a week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine–131. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

A matrix method (*6*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

FIGURE 8.—NEW YORK MILK SAMPLING LOCATIONS

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution; strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium–90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product yttrium–90. The monthly average radionuclide concentrations in milk are shown in table 7.

TABLE 7.—RADIONUCLIDES IN NEW YORK MILK, OCTOBER–DECEMBER 1963 [a]

[Average concentrations in pc/liter]

Sampling location	Strontium-89			Strontium-90			Cesium-137		
	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.
Albany	20	13	8	21	21	18	101	110	120
Buffalo	24	8	12	14	14	13	79	102	102
Massena	16	10	4	31	28	28	160	221	194
Newburgh	19	7	12	20	21	21	92	98	121
New York City	20	19	8	25	24	25	117	122	153
Syracuse	17	20	7	20	27	20	87	96	126
Average	19	13	9	22	23	21	106	125	134

[a] The monthly average I^{131} and $Ba\text{-}La^{140}$ at each station was <20 pc/liter.
Note: $Ba\text{-}La^{140}$ refers to the sum of these two nuclides in equilibrium.

6. Oregon Milk Network, November 1963-February 1964

Division of Sanitation & Engineering, Oregon State Board of Health

The Oregon State Board of Health conducts milk monitoring at eight major milk-producing centers throughout the State of Oregon, as shown in figure 9. Half-gallon samples of pasteurized packaged milk are collected Statewide on a monthly basis by the Oregon Department of Agriculture and weekly in the Portland area by the city of Portland. Milk sampling frequency is accelerated to a weekly schedule at those locations having radionuclide concentrations in milk in excess of 100 pc/liter for iodine–131 or 500 pc/liter for cesium–137 (suggestive of elevated strontium–90 concentrations). The samples are forwarded to the Oregon State Board of Health radiation laboratory for iodine–131, cesium–137, barium–140, and strontium–90 analyses. Gamma analyses are performed utilizing a 3″ x 3″ sodium iodide scintillation detector with a 512–channel gamma spectrometer system. Samples are normally counted for 100 minutes. The strontium–90 concentrations reported by the Oregon State Board of Health were analyzed using the trichloracetic acid analytical procedure (*7*) with the counting performed using a low background beta proportional counter. The minimum detectable concentrations for iodine–131, cesium–137, and barium–140 are 15 pc/liter. The minimum detectable concentration is defined to be that amount of activity which, in the same counting time, will exceed the background by 3σ (counting error) of the background.

Table 8 presents the Oregon milk surveillance data for the period November 1963 through February 1964. Figure 10 shows iodine–131, cesium–137, and strontium–90 concentrations

TABLE 8.—RADIONUCLIDE CONCENTRATIONS IN OREGON MILK, NOVEMBER 1963–FEBRUARY 1964 [a]

[Average concentrations in pc/liter]

Sampling location & frequency	Nuclide	November	December	January	February
Baker (monthly)	Sr^{90}	[b] —	—	—	26
	Cs^{137}	110	115	175	195
Coos Bay (monthly)	Sr^{90}	—	—	—	31
	Cs^{137}	315	255	190	240
Eugene (monthly)	Sr^{90}	—	—	—	19
	Cs^{137}	130	125	150	125
Medford (monthly)	Sr^{90}	—	—	—	13
	Cs^{137}	65	145	160	180
Nyssa (monthly)	Sr^{90}	—	—	—	13
	Cs^{137}	95	130	110	120
Portland Composite (weekly)	Sr^{90}	[c] 36	[c] 26	—	[d] 21
	Cs^{137}	190	165	175	130
Portland Local Producer (weekly)	Sr^{90}	—	—	—	[d] 25
	Cs^{137}	175	170	170	155
Redmond (monthly)	Sr^{90}	—	—	—	14
	Cs^{137}	110	115	155	155
Tillamook (weekly)	Sr^{90}	—	—	—	[d] 17
	Cs^{137}	380	340	200	160

[a] Iodine-131 and barium-140 concentrations were below lower limit of detection of 15 pc/liter. Unidentified radionuclides with a half-life of about 5 days interfered with some iodine-131 analyses.
[b] No analysis performed.
[c] Analysis by U.S. Public Health Service. All other analyses by Oregon State Board of Health.
[d] Monthly analysis.

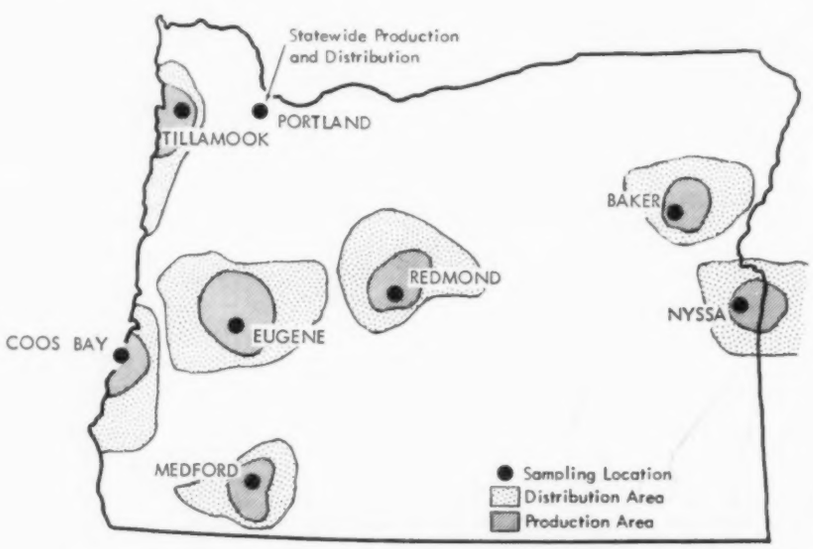
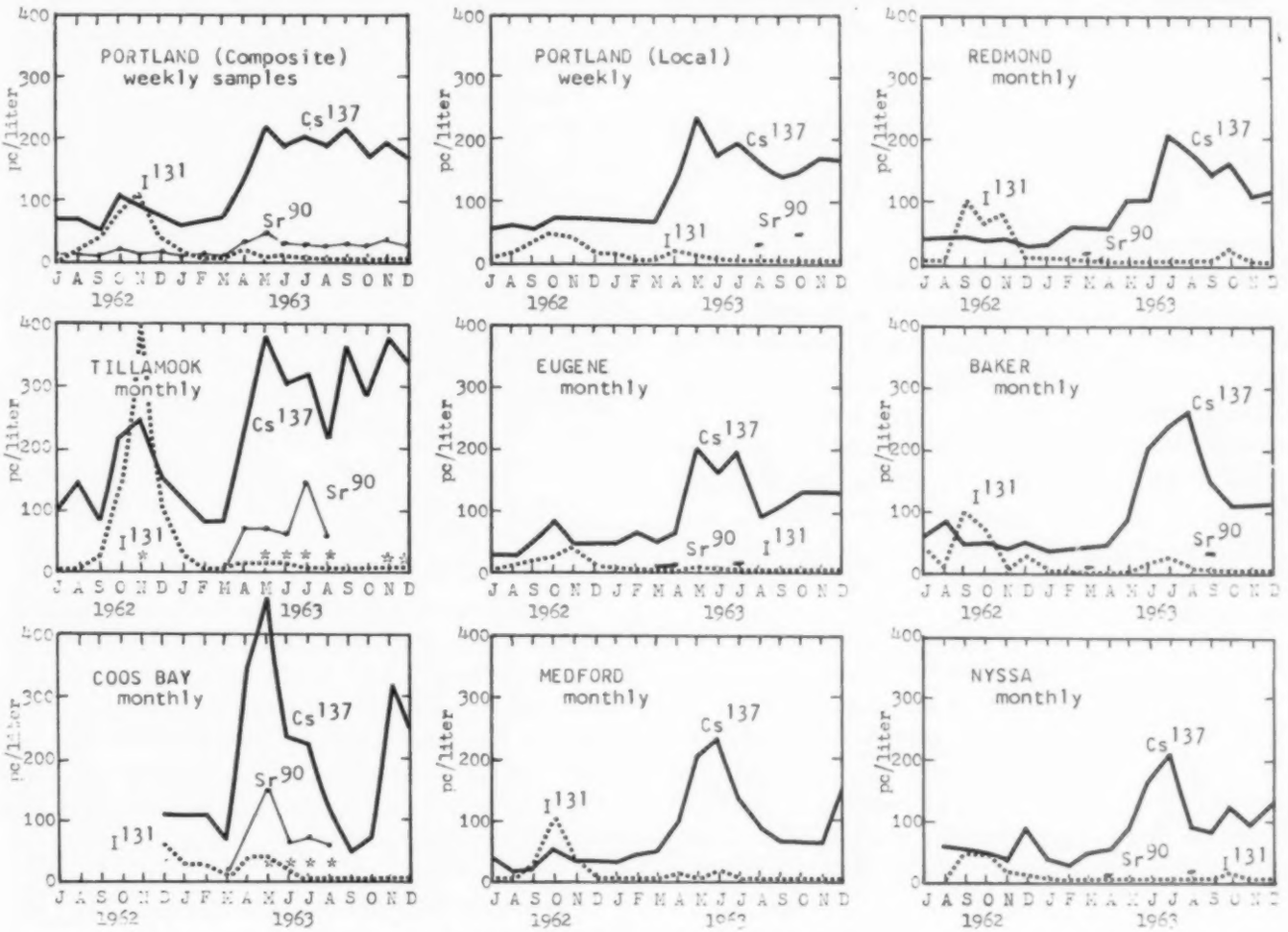


FIGURE 9.—OREGON PASTEURIZED MILK NETWORK SAMPLING LOCATIONS SHOWING PRODUCTION AND DISTRIBUTION AREAS

for all sampling locations. The Portland composite sample represents contributions from nearly all milksheds in Oregon, plus some in Southern Washington. Thus, it tends to represent a State average.

Previous coverage in *Radiological Health Data*

Period	Issue
November 1962-February 1963	*May 1963*
March-June 1963	*September 1963*
July-October 1963	*February 1964*



(* Sampling done on a weekly basis)

FIGURE 10.—RADIONUCLIDE CONCENTRATIONS IN OREGON MILK SAMPLES

7. Canadian Milk Network,[3] February 1964

Radiation Protection Division, Department of National Health and Welfare

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 11) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89, cesium–137 and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly pro-

[3] Data from *Radiation Protection Programs, Vol. 2, No. 3*:25–30, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (March 1964).

portional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, strontium–89, cesium–137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine–131 (*8*). Carrier iodine is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodide ion is oxidized to free iodine and extracted with carbon tetrachloride, back-extracted in sulfite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine–131 determined by comparison with standard preparations.

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet, and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter nuclide while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with standard preparations. The stable potassium content is estimated from the potassium–40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radio isotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide

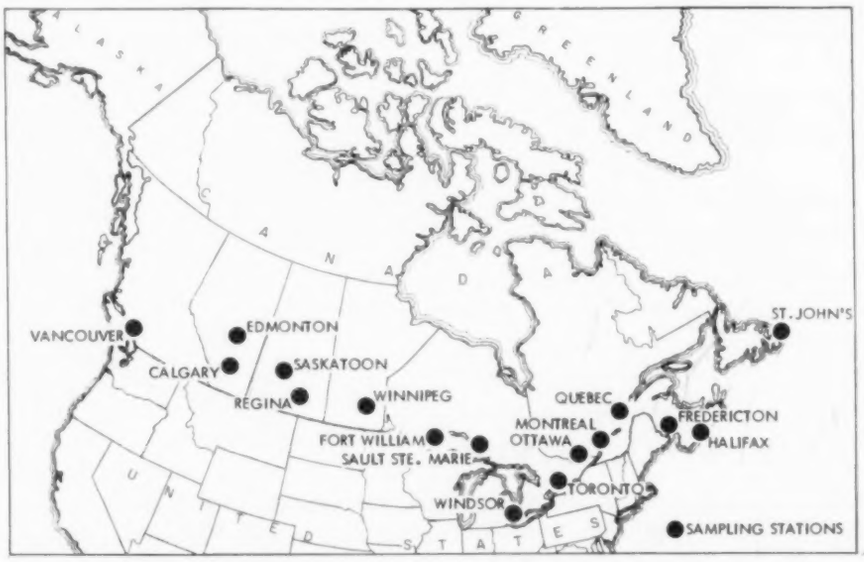


FIGURE 11.—CANADIAN MILK SAMPLING STATIONS

in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 9.

TABLE 9.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence.

TABLE 10.—CALCIUM, POTASSIUM AND RADIONUCLIDES IN CANADIAN WHOLE MILK, FEBRUARY 1964 [a]

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.35	1.5	52.1	290
Edmonton	1.38	1.6	35.1	244
Ft. William	1.33	1.6	52.1	300
Fredericton	1.44	1.7	55.6	379
Halifax	1.28	1.6	45.4	289
Montreal	1.26	1.7	38.4	274
Ottawa	1.29	1.7	32.7	230
Quebec	1.22	1.7	45.6	347
Regina	1.31	1.6	48.3	208
St. John's, Nfld	1.27	1.7	50.9	264
Saskatoon	1.31	1.6	48.2	222
Sault Ste. Marie	1.33	1.6	37.8	194
Toronto	1.35	1.7	19.9	140
Vancouver	1.35	1.6	36.6	269
Windsor	1.33	1.7	17.2	112
Winnipeg	1.23	1.6	45.6	244
Average	1.31	1.6	41.3	250

[a] Due to insignificant levels of Sr^{89} the reporting of this radionuclide has been discontinued.

Results

Table 10 presents monthly averages of strontium–89, strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 indicate that all samples had <5 pc/liter.

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MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, MARCH 1963—FEBRUARY 1964

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to estimate the contribution of milk to a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of a representative individual in a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium–89, strontium–90, iodine–131 and cesium–137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2*, *3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all foods, and milk levels provide an index of general intake trends. The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and one third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptance risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3*, *4*).

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as weather conditions and dairying practices. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

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[1] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously 5 pc/liter was used in calculating the average.

Table 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Feb. 1963—Jan. 1964 [a]	Mar. 1963—Feb. 1964 [b]	Feb. 1963—Jan. 1964 [a]	Mar. 1963—Feb. 1964 [b]	Feb. 1963—Jan. 1964 [a]	Mar. 1963—Feb. 1964 [b]	Feb. 1963—Jan. 1964 [a]	Mar. 1963—Feb. 1964 [b]
Ala:	Montgomery	53	46	21	22	3	3	80	85
Alaska:	Palmer	29	29	22	23	3	3	123	132
Ariz:	Phoenix	11	9	4	4	3	3	22	22
Ark:	Little Rock	101	91	43	43	5	3	154	160
Calif:	Sacramento	37	36	10	11	3	3	61	63
	San Francisco	67	62	14	14	3	3	74	77
Colo:	Denver	25	24	17	17	5	4	84	86
Conn:	Hartford	21	21	24	24	3	3	152	161
Del:	Wilmington	27	27	25	25	4	3	127	133
D. C:	Washington	37	37	20	20	3	3	96	100
Fla:	Tampa	28	24	14	15	5	3	221	225
Ga:	Atlanta	76	67	30	31	4	3	142	148
Hawaii:	Honolulu	31	28	11	11	5	3	75	76
Idaho:	Idaho Falls	49	47	24	27	3	3	140	154
Ill:	Chicago	18	18	21	21	3	3	107	113
Ind:	Indianapolis	28	27	23	24	3	3	97	102
Iowa:	Des Moines	56	54	25	26	3	3	91	93
Kans:	Wichita	39	37	19	20	3	3	72	74
Ky:	Louisville	82	79	32	33	3	3	108	113
La:	New Orleans	123	101	43	44	7	5	154	156
Maine:	Portland	26	25	31	32	3	3	200	209
Md:	Baltimore	46	45	21	21	3	3	119	123
Mass:	Boston	31	30	34	36	3	3	219	232
Mich:	Detroit	16	16	20	20	3	3	110	114
	Grand Rapids	17	17	20	21	4	3	115	120
Minn:	Minneapolis	47	46	30	32	3	3	148	153
Miss:	Jackson	115	98	36	37	5	3	113	116
Mo:	Kansas City	63	61	27	28	3	3	83	86
	St. Louis	46	45	22	23	3	3	85	88
Mont:	Helena	45	43	27	28	4	3	171	182
Nebr:	Omaha	47	46	25	26	3	3	95	97
Nev:	Las Vegas	17	15	9	10	4	3	69	72
N. H:	Manchester	29	28	33	34	5	3	242	254
N. J:	Trenton	21	21	21	22	3	3	119	124
N. Mex:	Albuquerque	19	18	10	10	3	3	43	46
N. Y:	Buffalo	21	21	23	23	3	3	133	141
	New York	29	29	29	30	3	3	156	165
	Syracuse	24	23	23	24	4	3	130	138
N. C:	Charlotte	63	61	31	32	3	3	119	123
N. Dak:	Minot	81	80	50	53	4	3	136	143
Ohio:	Cincinnati	34	33	26	26	4	3	89	95
	Cleveland	23	22	21	22	3	3	105	110
Okla:	Oklahoma City	58	53	23	24	4	3	87	90
Ore:	Portland	67	63	29	31	3	3	157	162
Pa:	Philadelphia	25	25	24	23	3	3	120	126
	Pittsburgh	33	32	29	29	4	3	144	151
P. R:	San Juan	57	45	14	14	6	3	88	87
R. I:	Providence	25	25	27	28	4	3	159	169
S. C:	Charleston	59	47	27	28	5	3	123	128
S. Dak:	Rapid City	64	62	37	40	4	3	147	154
Tenn:	Chattanooga	95	91	37	39	3	3	140	146
	Memphis	80	73	31	32	3	3	88	90
Tex:	Austin	25	22	9	9	3	3	45	47
	Dallas	58	51	21	21	5	3	80	82
Utah:	Salt Lake City	32	31	23	24	5	4	153	162
Vt:	Burlington	25	25	28	29	3	3	171	181
Va:	Norfolk	43	40	22	22	3	3	100	103
Wash:	Seattle	53	51	25	25	3	3	149	150
	Spokane	49	47	27	29	4	3	137	141
W. Va:	Charleston	64	62	29	30	4	3	98	103
Wis:	Milwaukee	18	17	19	19	4	3	113	121
Wyo:	Laramie	37	35	21	22	3	3	115	115
Network average		45	42	24.4	25.2	4	3	119	124

[a] Annual averages were computed on basis of 52 weekly averages.

[b] Annual averages were computed on basis of 53 weekly averages.

STRONTIUM-90 IN 1963 UNITED STATES WHEAT

V. F. Pfeifer and A. J. Peplinski[1]

Studies are being conducted by the United States Department of Agriculture's Northern Regional Research Laboratory to develop processing methods for reducing strontium–90 in wheat and milling products, should this become necessary. The first phase of these studies was the analysis of 1963 wheat samples from major U. S. wheat producing areas. This crop year was chosen because strontium–90 levels were expected to be the highest for several years, according to Federal Radiation Council predictions (*1*).

Wheat samples of at least 100 pounds for each variety were procured from commercial producers in 6 States. Each lot of wheat was blended thoroughly, sampled, and cleaned in a dockage tester to remove chaff and dust before analysis. Analyses for strontium–90 were performed by a contractor using analytical procedures described by Harley (*2*). Analyses for protein, ash, and calcium were made at this laboratory using Cereal Laboratory Methods 46–10, 08–01, and 40–20, respectively (*3*).

The results in table 1 show that the lowest levels of strontium–90 contamination were in the Pacific Northwest soft white winter (SWW) wheats and in the Ohio soft red winter (SRW) wheats. Highest levels were found in the Kansas hard red winter (HRW) wheats. These results indicate levels reached in 1963; sampling was not sufficiently extensive to be considered representative.

The three Pacific Northwest wheats, grown on the same type of soil in the Pullman, Washington, area, varied in strontium–90 content from 76 to 119 pc/kg (dry weight). The six Indiana SRW wheats, grown in the Huntingdon area on the same type of soil, had strontium–90 levels ranging from 258 to 338 pc/kg. Wichita and Comanche varieties of HRW wheat, grown on the same type of soil in the Kinsley, Kansas, area, had practically identical strontium–90 levels.

The 1963 strontium–90 levels in wheat are about three times as high as the 1962 levels (*4*), confirming the predictions of 250 pc/kg by the Federal Radiation Council (*1*) and 200–300 pc/kg by Rivera (*5*).

TABLE 1.—STRONTIUM-90 IN U.S. WHEATS HARVESTED IN 1963

[Calculated on dry basis [1]]

Variety	Class	Grown in vicinity of:	Protein (Percent)	Ash (Percent)	Calcium (Percent)	Strontium-90 (pc/kg)
Brevor	[2] SWW	Pullman, Wash.	12.2	1.70	0.037	90
Gaines	SWW	Pullman, Wash.	9.0	1.60	0.036	76
Omar	Club	Pullman, Wash.	9.0	1.60	0.039	119
Lakota	Durum	Carrington, N. Dak.	17.4	1.89	0.036	147
Wells	Durum	Carrington, N. Dak.	18.4	1.84	0.037	182
Tascosa	[3] HRW	Johnson, Kans.	14.0	2.02	0.054	495
Kaw	HRW	Johnson, Kans.	13.6	1.93	0.045	359
Wichita	HRW	Kinsley, Kans.	14.3	1.91	0.056	253
Comanche	HRW	Kinsley, Kans.	13.7	1.70	0.056	250
Ponca	HRW	Partridge, Kans.	17.2	1.71	0.058	253
Pawnee	HRW	Partridge, Kans.	13.6	1.58	0.043	439
Triumph	HRW	Partridge, Kans.	15.3	1.72	0.039	465
Bison	HRW	Hays, Kans.	15.9	1.77	0.057	417
Ponca	HRW	Peoria, Ill.	11.3	1.96	0.039	87
Dual	[4] SRW	Huntingdon, Ind.	12.9	1.97	0.050	338
Vermillion	SRW	Huntingdon, Ind.	12.2	1.81	0.048	319
Reed	SRW	Huntingdon, Ind.	14.1	1.89	0.042	329
Laporte	SRW	Huntingdon, Ind.	13.8	1.65	0.041	258
Redcoat	SRW	Huntingdon, Ind.	13.3	2.09	0.050	285
Monon	SRW	Huntingdon, Ind.	12.2	2.01	0.038	296
Seneca	SRW	Sandusky, Ohio	11.8	1.77	0.049	111
Lucas	SRW	Sandusky, Ohio	10.7	1.56	0.037	60
Thorne	SRW	Sandusky, Ohio	11.2	1.81	0.049	110

[1] Wheat moisture contents varied from 10.3 to 14.0 percent.
[2] SWW indicates soft white winter wheat.
[3] HRW indicates hard red winter wheat.
[4] SRW indicates soft red winter wheat.

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STRONTIUM-90 IN PLANT PARTS AND MILLING FRACTIONS FROM A 1963 ILLINOIS WHEAT

V. F. Pfeifer, A. J. Peplinski, and J. E. Hubbard[1]

Plant parts and milling fractions of wheat are being analyzed for strontium–90 as a part of the studies by the U. S. Department of Agriculture's Northern Regional Research Laboratory to develop processing methods for reducing the radionuclide content of these products, should this become necessary.

Following nuclear testing through 1962, levels of radioactive contamination of wheat were predicted to reach maximum values in 1963 and then to decrease (*1*). Therefore, a field of wheat in central Illinois was chosen for collection of 1963 wheat plants and field-combined wheat to obtain data on strontium–90 in aboveground plant parts and in milling fractions from both hand-separated and field-combined wheats from the same field. Strontium–90 in wheats and milling products for previous years has been reported by Rivera (*2–4*).

Procedures

Ponca hard red winter wheat plants, 1963 crop, grown on a field in Hollis Township, Peoria County, Illinois, were cut near the ground, and about 100 pounds of the aboveground parts were hand-separated to provide sufficient quantities of leaves, stems, rachises, chaff, and wheat kernels for analyses and determination of weight distribution of the parts. Enough additional plants were hand-threshed and hand-separated to provide sufficient wheat for milling in a Buhler experimental flour mill.[2] The hand-separated wheat kernels were cleaned in a Bates laboratory aspirator before milling. About 30 pounds of wheat combined in the same field were mechanically cleaned by several passages through a Federal dockage tester, and the cleaned wheat was milled in a Miag Multomat experimental flour mill. Strontium–90 analyses of plant parts and milling fractions were done by a contract laboratory using analytical procedures described by Harley (*5*). Analyses for protein, ash, and calcium were made at the Northern Laboratory, using Cereal Laboratory Methods 46–10, 08–01, and 40–20, respectively (*6*).

Results and Discussion

The weight distribution measurement and chemical analyses of the aboveground plant parts are given in table 1. Milling results and chemical analyses of the various fractions obtained after milling the hand-separated kernels are given in table 2. Milling results and chemical analyses of fractions obtained after milling the field-combined wheat are given in table 3.

The nitrogen content of all plant parts except leaves and kernels was low. Patent and first clear flours were lower in protein content than the wheat, whereas second clear flour, shorts, and bran were all higher in protein content than the original grain. After milling, the flour retained about one-fourth of the calcium but less than one-fifth of the ash.

Although the wheat kernels amounted to almost one-half of the weight of the aboveground plants, they contained less than one-tenth of the total strontium–90 present in the plants. Highest concentrations were in the leaves and in the chaff, and these two fractions together contained about three-fourths of that present. In the plant parts, strontium–90/calcium ratios ranged from 212 pc strontium–90/gram calcium in the kernels to 1206 in the chaff. Strontium–90 in the ash ranged from 3.8 pc/gram in the kernels to about 22 in the leaves and rachises, but was only 11.3 in the chaff.

Wheat kernels separated by hand-picking, and cleaned by aspiration, contained somewhat less strontium–90 than did the field-combined, mechanically cleaned wheat; all milling fractions from the hand-separated wheat contained less strontium–90 than corresponding fractions from the field-combined wheat. The importance of cleaning wheat properly before milling is thus demonstrated, since the Miag mill, with its longer and more extensive milling flow,

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[2] Mention of firm names or trade products does not imply that they are endorsed or recommended by the Department of Agriculture over other firms or similar products not mentioned.

TABLE 1.—WEIGHT DISTRIBUTION AND ANALYSES OF ABOVEGROUND WHEAT PLANT PARTS

[Analyses on dry basis]

Aboveground plant part	Weight (Percent)	Nitrogen (Percent)	Ash (Percent)	Calcium (Percent)	Sr^{90} (pc/kg)	Sr^{90} in fraction (Percent of total)
Stems	25.2	0.27	3.00	0.063	310	14
Leaves	10.3	0.74	8.69	0.206	1904	36
Rachises	2.6	0.35	3.22	0.082	738	4
Chaff (glumes, awns etc.)	14.3	0.03	13.19	0.124	1495	39
Wheat kernels	47.6	2.01	2.01	0.036	76	7

TABLE 2.—STRONTIUM-90 IN MILLING FRACTIONS FROM HAND-PICKED WHEAT KERNELS

[Analyses on dry basis]

Fraction	Yield (Percent)	Protein (Percent)	Ash (Percent)	Calcium (Percent)	Sr^{90} (pc/kg)	Sr^{90} in fraction (Percent of total)
Wheat	—	11.5	2.01	0.036	[a] 76.5	100
Patent flour	57.7	9.9	0.49	0.011	10.3	8
Clear flour	13.2	10.9	0.62	0.014	17.3	3
Shorts	7.5	[b] 16.9	3.21	0.060	113	11
Bran	21.6	[b] 15.1	6.65	0.114	282	78

[a] Sr^{90} in wheat, calculated from milling fractions = 77.6.
[b] Nitrogen content × 6.25.

should have given a better separation of flour and feed fractions than the Buhler mill.

In the milling fractions from the hand-picked wheat, strontium–90/calcium ratios varied from 94 pc strontium–90/gram calcium in the patent flour to 247 in the bran, with 212 in the wheat. Strontium–90 in the ash varied from 2.1 pc/gram in the patent flour to 4.2 in the bran, with 3.8 in the wheat.

In the milling fractions from the field-combined wheat, strontium–90/calcium ratios varied from 131 pc strontium–90/gram calcium in the patent flour to 313 in the bran, with 223 in the wheat. Strontium–90 in the ash varied from 4.0 pc/gram in the patent flour to 6.6 in the shorts, with 4.4 in the wheat.

Considering that each one-pound loaf of white bread contains nearly two thirds of a pound (about 280 grams) of white flour, the importance of effective milling for reducing strontium–90 in the flour, and the need for diverting the more highly-contaminated bran and shorts fractions to feeds can be appreciated. The flour milled from wheat contains only about 1 percent of the total strontium–90 present in the aboveground wheat plants. Wheat is thus a good raw material for producing fractions suitable for use in foods under conditions of high-density fallout, although accompanying diet modification might be required with prolonged and concentrated consumption.

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STRONTIUM-90 AND CALCIUM IN TRI-CITY DIETS, AUGUST–OCTOBER 1963[1]

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Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium–90. Using data from the U. S. Department of Agriculture (*1*), the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium–90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general. Details of the sampling system and assumptions as to the amounts of specific foods consumed per year have been published (*2*).

The consumption data from the "Household Food Survey of 1955" are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. The specific numbers used to calculate calcium intake are given in HASL–113 (*3*).

To increase the validity of this estimate an additional set of diet samples from each city have recently been analyzed for calcium. The results of these analyses together with those previously obtained are presented in table 1. The estimated average yearly intake of calcium calculated using all of the data remains at 383 g/year. No essential differences in the calcium content of foods purchased at each city were noted. There was also no evidence of changes in calcium concentrations of foods with time. In view of these findings, routine calcium analyses of tri-city foods will no longer be done.

Results obtained from the program's fourteenth sampling (August–October 1963) are presented in table 2. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1.

Discussion

The daily intakes of strontium–90 at New York City and Chicago are seen to be more nearly the same during the last half of 1963 than they were for the first half of the year. The daily intake of strontium–90 in New York City seems to have leveled off at about 35 pc/day and it is likely that the intake at Chicago also leveled off during late 1963 at a value slightly less than that of New York. The daily intake of strontium–90 at San Francisco appeared to have passed its peak for 1963, but results of the December sampling will have to be evaluated before this is established with certainty.

If for a given dietary regimen the ratio of Sr^{90}/Ca (strontium units) in the total diet to Sr^{90}/Ca in milk is constant, then estimates of total diet Sr^{90}/Ca could be made using only data on the Sr^{90}/Ca of milk.

The total diet-milk Sr^{90}/Ca ratios obtained using data from the Tri-City Diet Studies are plotted in figure 2. From this graph the ratio is seen to have varied from 1.0 to 2.0, with no apparent trend with time or difference among

[1] Summarized from *Health and Safety Laboratory, AEC, Fallout Program Quarterly Summary Report, HASL 144:* 281–7, Office of Technical Services Department of Commerce, Washington, D. C. 20230, (April 1, 1964), price $4.00.

[2] Mr. Rivera is a physicist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U. S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

cities noted, since 1960. If a mean value of 1.5 were taken for the total diet-milk ratio, then estimates of total diet Sr^{90}/Ca made from milk Sr^{90}/Ca would not have been in error by more than ±50%.

The relative constancy of the diet-milk ratio implies that the Sr^{90}/Ca of the non-milk component of the diet has been roughly proportional to the Sr^{90}/Ca of milk. The Sr^{90}/Ca ratios of the non-milk components and the milk components of the diet in New York, Chicago, and San Francisco are plotted in figures 3 and 4, respectively. The ratio of these values (Sr^{90}/Ca of non-milk component ÷ Sr^{90}/Ca of milk component) is shown in figure 5. For each city it appears that on the average the Sr^{90}/Ca of the non-milk component of the diet has been about twice that of milk.

TABLE 1.—CALCIUM IN DIETARY CONSTITUENTS AND CALCULATED ANNUAL CALCIUM INTAKES

Food category	Average U.S. consumption (kg/yr)[1]	Grams of calcium per kilogram of original material									Mean ± standard deviation g (Ca/kg)	Calcium intake (g/yr)
		New York			Chicago			San Francisco				
		3/60	6/60	11/63	5/60	9/60	11/63	3/60	8/60	11/63		
White bread	37	0.74	1.30	1.62	0.92	1.25	0.91	0.81	1.09	1.05	1.06±0.27	39.2± 1.0
Whole wheat bread	11	0.68	0.98	1.16	0.05	1.04	0.85	0.93	0.90	0.79	0.92±0.14	10.1± 1.5
Eggs	16	1.78	0.58	0.58	0.54	0.47	0.66	0.65	0.61	0.56	0.58±0.42	9.3± 6.7
Fresh vegetables	43	0.47	0.32	0.38	0.36	0.34	0.35	0.27	0.35	0.32	0.35±0.05	15.0± 2.1
Root vegetables	17	0.57	0.32	0.26	0.38	0.16	0.44	0.41	0.31	0.44	0.37±0.12	6.3± 0.20
Milk	221	1.05	1.09	1.09	0.99	1.09	0.92	1.05	1.08	1.15	1.06±0.06	231.3±13.3
Chicken	17	0.36	0.15	0.35	0.79	1.04	0.40	0.32	0.58	0.33	0.48±0.27	8.2± 4.6
Fresh fish	8	1.61	1.10	0.14	1.55	1.26	0.55	1.24	0.64	1.33	1.12±0.43	9.0± 3.4
Flour	43	0.21	0.18	0.19	0.20	0.09	0.23	0.20	0.19	0.19	0.20±0.04	8.6± 1.7
Macaroni	3	0.23	0.18	0.16	0.22	0.26	0.22	0.20	0.22	0.23	0.21±0.03	0.6± 0.09
Rice	3	0.49	0.38	0.20	0.19	0.25	0.21	0.30	0.58	0.31	0.32±0.13	1.0± 0.4
Meat	73	0.09	0.09	0.30	0.09	0.09	0.14	0.14	0.42	0.08	0.16±0.12	11.7± 8.3
Shellfish	1	1.34	0.75	2.64	0.59	0.48	0.45	0.79	0.88	2.74	1.17±0.49	1.17±0.9
Dried beans	3	0.59	0.68	0.84	1.45	1.16	1.68	1.05	0.84	1.14	1.05±0.38	3.1± 1.1
Fresh fruit	68	0.16	0.21	0.12	0.21	0.23	0.16	0.31	0.05	0.22	0.19±0.07	12.9± 4.8
Potatoes	45	0.08	0.16	0.06	0.14	0.10	0.12	0.16	0.12	0.08	0.11±0.03	4.9± 1.3
Canned fruit	26	0.05	0.05	0.04	0.05	0.05	0.07	0.05	0.05	0.04	0.05±0.09	1.3± 0.0
Fruit juices	19	0.09	0.09	0.08	0.08	0.11	0.14	0.08	0.14	0.10	0.09±0.02	1.7± 0.04
Canned vegetables	20	0.14	0.23	0.22	0.20	0.23	0.22	0.25	0.23	0.23	0.21±0.03	4.2± 0.6
Average total calcium intake per year (grams/year)												382.6±19.2

[1] Based on USDA Household Food Consumption Survey (*1*).

TABLE 2.—AVERAGE PER PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE—FOURTEENTH SAMPLING

Food category	Average U.S. consumption		New York City August 1963		Chicago October 1963		San Francisco September 1963	
	diet (kg/yr)	Calcium (g/yr)	(pc/kg)[a]	(pc/yr)	(pc/kg)[a]	(pc/yr)	(pc/kg)[a]	(pc/yr)
Bakery products	37	37.0	22.9±1.1	847	29.2±1.1	1080	16.5±1.1	610
Whole grain products	11	10.0	28.1±1.2	309	72.6±1.9	799	27.4±1.4	301
Eggs	16	9.1	11.2±0.3	179	6.0±0.3	96	3.3±0.2	53
Fresh vegetables	43	15.0	13.5±0.8	580	26.0±0.7	1118	3.3±0.3	142
Root vegetables	17	6.1	5.2±0.3	88	10.5±0.6	178	6.4±0.5	109
Milk	221	234.3	41.9±0.9	9260	19.6±0.6	4332	7.0±0.4	1547
Poultry	17	9.2	3.2±0.1	54	3.0±0.1	51	2.1±0.1	36
Fresh fish	8	10.8	1.1±0.1	9	1.9±0.1	15	1.1±0.1	9
Flour	43	8.6	17.9±0.4	770	29.8±7.0	1281	22.9±0.6	985
Macaroni	3	0.7	9.4±0.4	28	22.6±0.5	68	12.0±0.5	36
Rice	3	1.1	2.6±0.3	8	5.9±0.3	18	7.4±0.4	22
Meat	73	10.9	1.4±0.1	102	2.1±0.1	153	2.7±0.1	197
Shellfish	1	0.8	5.8±0.2	6	0.9±0.3	1	1.8±0.2	2
Dried beans	3	2.9	14.8±1.7	44	37.9±1.9	114	18.5±2.3	56
Fresh fruit	68	13.6	3.2±0.2	218	2.8±0.1	190	2.8±0.3	190
Potatoes	45	5.8	10.1±0.8	454	4.5±0.5	202	3.2±0.6	144
Canned fruit	26	1.3	1.9±0.1	49	2.7±0.1	70	2.5±0.2	65
Fruit juices	19	1.7	5.2±0.4	99	4.1±0.3	78	4.2±0.3	80
Canned vegetables	20	4.2	7.8±0.6	156	18.4±0.7	368	2.5±0.4	50
Annual Intake		674	383	13,260		10,212		4634
pc Sr^{90}/g Ca in total diet				34.6		26.7		12.1

[a] Error terms are one standard deviation (due to counting).

Another inference that can be drawn is that the relatively low Sr^{90}/Ca of the non-milk components of the diet in San Francisco are probably due to the consumption of locally-produced foods. Thus, despite the wide distribution of foods in the United States, foods produced in the relatively low fallout regions of California were probably the principle sources of the non-milk foods consumed in San Francisco.

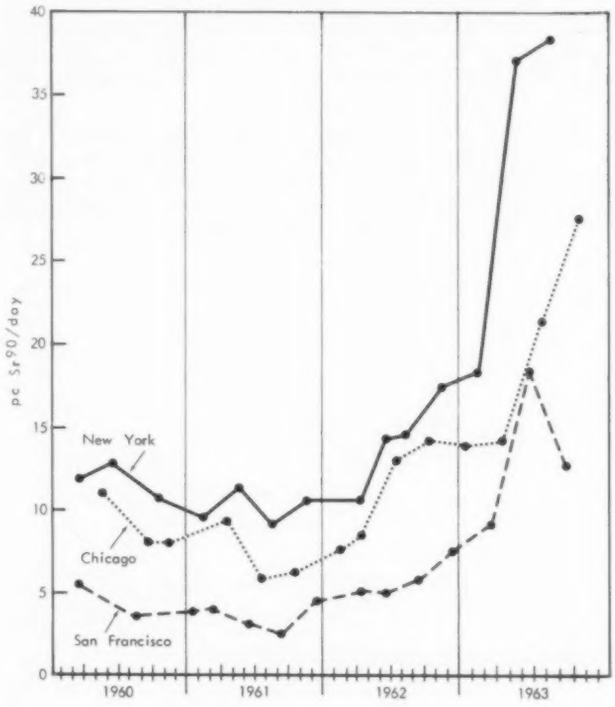

FIGURE 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

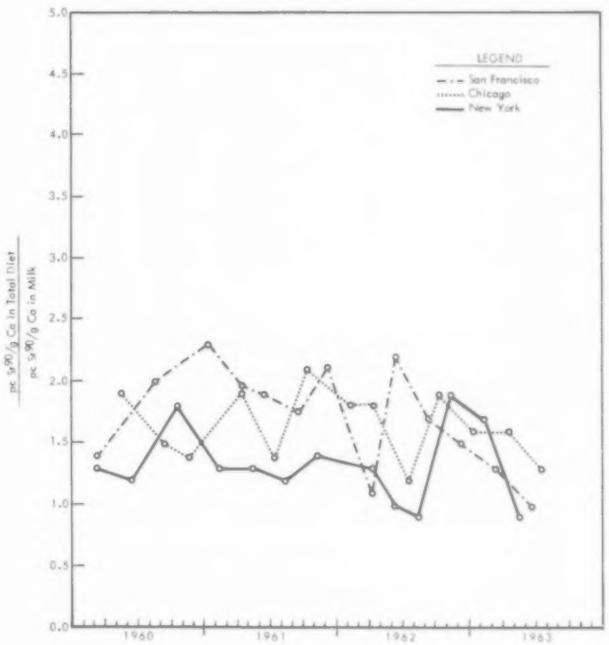

FIGURE 2.—RATIO OF STRONTIUM UNITS IN TOTAL DIET TO STRONTIUM UNITS IN MILK

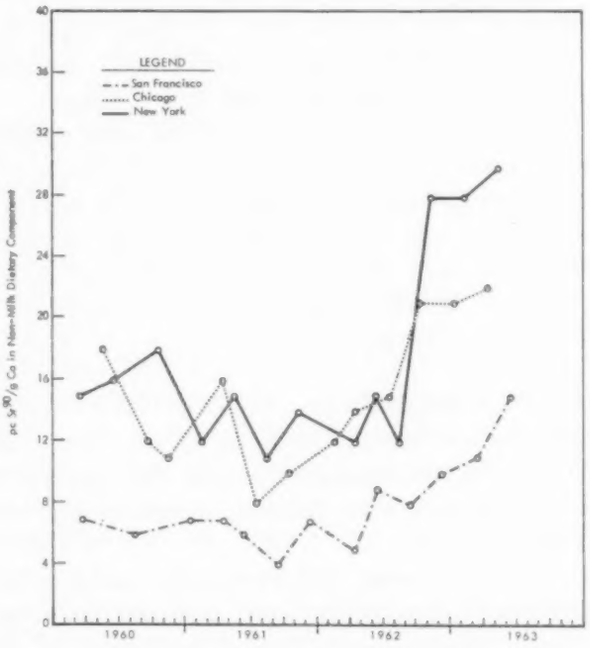

FIGURE 3.—STRONTIUM UNITS IN NON-MILK COMPONENTS OF TRI-CITY DIETS

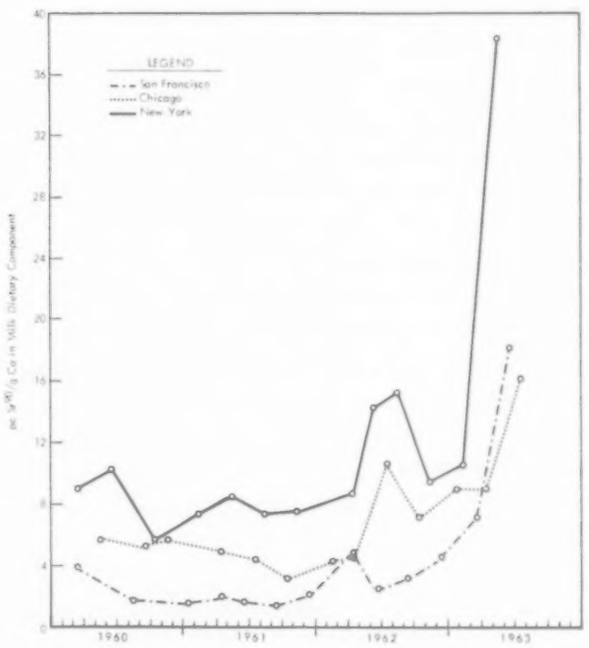

FIGURE 4.—STRONTIUM UNITS IN THE MILK COMPONENTS OF TRI-CITY DIETS

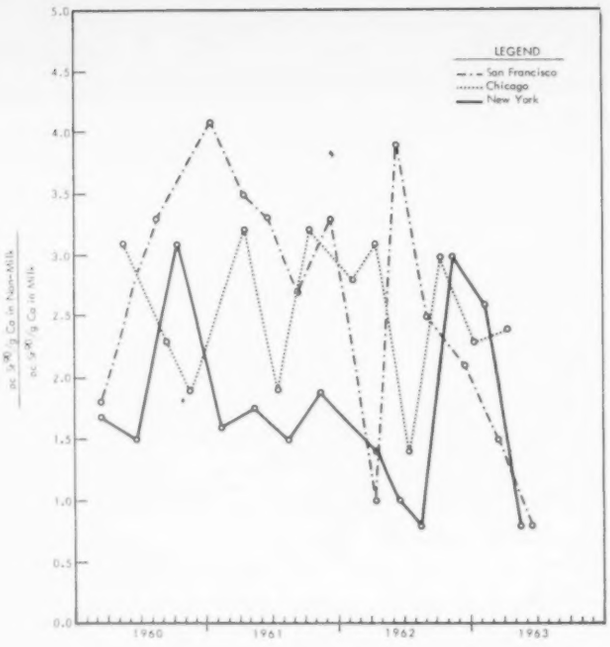

FIGURE 5.—RATIO OF STRONTIUM UNITS IN NON-MILK COMPONENTS OF TOTAL DIET TO STRONTIUM UNITS IN MILK

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CESIUM-137 IN TRI-CITY DIETS,[1] AUGUST–OCTOBER 1963

J. Rivera and J. J. Kelly[2]

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diets of individuals living in New York City, San Francisco, and Chicago (see preceding article, p. 2–42). Occasionally, some samples from this study are analyzed for other radionuclides. The samples for October-December 1963 were analyzed for the fission product cesium–137.

Because Cs^{137} is thought to be less hazardous than Sr^{90}, comparatively little effort has been made in this country to measure its concentration in the diet as a whole, or in components of the diet. Anderson *et al.* (*1*) showed that Cs^{137} levels in fallout, milk, and people could be related, but a number of assumptions as to the magnitude of the contamination of non-milk fractions of the diet, and the time lag between production and consumption of these foods had to be made before good agreement between observation and theory could be obtained.

In an attempt to verify these assumptions and to obtain more data on which to base predictions of future body levels of Cs^{137} in humans, a limited number of samples from the Tri-City Diet Study are being analyzed for Cs^{137}. The results of the first set of these analyses are presented in table 1.

Analytical Method

The radiochemical analysis of the food composites was accomplished using the method of Collins, Sutton, and Solazzi, developed in this laboratory (*2*).

Cesium–137 and added cesium carrier are equilibrated by fusion with sodium carbonate or, with soluble samples, by digestion of the sample in nitric acid. Bulk constituents, including iron, the alkaline earths and the rare earths, are removed by leaching the alkali metals from

[1] Data from *Health and Safety Laboratory, AEC, Fallout Program Quarterly Summary Report, HASL–144:* 288–90, Office of Technical Services, Department of Commerce, Washington, D. C. 20430 (April 1, 1964), price $4.00.

[2] Mr. Rivera is a physicist and Mr. Kelly is a chemist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND CESIUM-137 INTAKE, OCTOBER–DECEMBER 1963

Food category	U.S. consumption (kg/yr)	New York City November 1963		Chicago October 1963		San Francisco December 1963	
		pc/kg [a]	pc/yr	pc/kg [a]	pc/yr	pc/kg [a]	pc/yr
White bread	37	95.7±2.8	3,541	87.5±2.6	3,237	867.4± 8.4	32,092
Whole grain bread	11	239.5±4.7	2,634	181.5±3.9	1,997	877.7± 8.2	9,655
Eggs	16	33.0±0.5	528	33.1±0.4	534	6.8± 0.5	108
Fresh vegetables	43	18.7±0.7	804	14.8±0.8	636	31.3± 1.2	1,346
Root vegetables	17	26.3±0.9	447	15.2±0.9	258	24.8± 1.0	422
Milk	221	135.1±1.9	29,857	69.6±1.3	15,382	59.3± 1.2	13,105
Poultry	17	40.3±0.4	685	69.7±0.6	1,184	36.0± 0.7	612
Fresh fish	8	166.5±1.4	1,332	32.2±0.3	257	11.7± 0.1	93
Flour	43	151.3±1.9	6,506	82.5±1.3	3,545	303.0± 2.2	13,027
Macaroni	3	144.1±1.8	432	175.6±2.0	547	123.7± 1.7	371
Rice	3	130.3±1.7	391	52.4±1.0	157	181.8± 2.3	545
Meat	73	9.1±0.3	664	116.8±0.8	8,526	130.1± 0.8	9,496
Shellfish	1	13.0±0.5	13	6.3±1.7	6	54.2± 3.8	54
Dried beans	3	308.1±6.2	924	319.0±6.0	957	982.5±15.0	2,947
Fresh fruit	68	41.1±0.9	2,795	42.9±0.8	2,916	27.2± 0.7	1,846
Potatoes	45	61.1±1.7	2,749	13.3±0.9	597	19.9± 0.9	897
Canned fruit	26	21.5±0.4	559	19.5±0.4	508	85.2± 0.8	2,214
Fruit juices	19	68.3±1.3	1,298	36.4±0.9	692	318.5± 2.6	6,052
Canned vegetables	20	44.4±1.3	888	22.8±0.9	455	322.2± 3.7	6,444
Annual Intake	674		57,047		42,371		101,326
Daily Intake (pc/day)			156		116		278

[a] Error terms are one standard deviation (due to counting).

the fusion melt with water or by scavenging the hydrochloric acid solution with $Ca_3(PO_4)_2$ or $CaCO_3$. Calcium, rubidium and potassium are extracted from solution with solid ammonium phosphomolybdate (APM) and cesium is purified by absorption and selective elution from a cation exchange resin.

Chemical yield is determined by weighing the final cesium fraction as the tetraphenylborate. The Cs^{137}–Ba^{137} beta activity is measured using a thin window Geiger-Mueller counter or a plastic beta scintillation counter. The instrument response is corrected for counter background and efficiency, self absorption, and yield.

To establish the precision of the method when routine samples were being processed, three sets of blind duplicates were included with the other samples. The results indicated that the reproducibility of analyses was better than ± 10 percent. Three $Ca_3(PO_4)_2$ samples were also analyzed. In each case, Cs^{137} was undetectable, indicating that there was no Cs^{137} contamination and that therefore no reagent blank corrections were necessary.

An estimate of the accuracy of the method can be made by comparison of results among laboratories using different methods. Such a comparison made by analyzing a wheat and powdered milk sample obtained from the International Atomic Energy Agency showed that HASL results were within one standard deviation of the mean values reported by six other laboratories.

The results obtained from the analyses of nine monthly milk samples from a number of different cities were found to average about 25 percent lower than those reported by the Public Health Service. This intercomparison is not conclusive, however, since the Public Health Service results were obtained from pooled samples while in most cases the HASL data are from single samples. It is possible that a small ($<10\%$) fraction of the Cs^{137} in milk and perhaps in other foods was lost via volatilization during sample preparation. Experiments comparing results obtained on samples prepared by wet and dry ashing are currently in progress to establish quantitatively what effect this has on Cs^{137} recovery.

Discussion

Although conclusions from preliminary data are speculative, it appears that the elevated levels of cereal products observed in San Francisco sampling indicate that products from a different wheat crop than that being used in New York City or Chicago had reached the San Francisco market in December.

Since the 1963 wheat crop probably had a higher Cs^{137} contamination than any previous

crop, it is likely that cereal products will contribute significantly to the daily intake of Cs^{137} and may become as important as milk and meat as dietary sources of Cs^{137}.

If dietary levels of Cs^{137} persist at about 200 pc/day, this would result in a body burden of roughly 20 nc. This body burden would result in a dose rate of only $^1/_{10}$ that due to natural potassium in the body.

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Section III—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, DECEMBER 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service Water Pollution Surveillance System (formerly National Water Quality Network) since its initiation in 1957. Beginning with the establishment of 50 sampling points, this System has expanded to 128 stations as of May 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the System provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System are published in an annual compilation (*1–7*).

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, DECEMBER 1963

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the Surveillance System Laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium–90 activity in the total solids are carried out on frequency schedules based on need.

Presently, gross alpha and beta determinations are made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established System stations. Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample when the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium–90 analyses have been made on three-month composites of aliquots from weekly samples. Beginning in November 1962, two quarterly samples per year have been analyzed for strontium–90 at each sampling point except those stations immediately below nuclear installations. At these stations four determinations per year are performed. The method used for determining strontium–90 is a modification of a procedure described by Harley (*9*). The yttrium–90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background anticoincidence, end-window proportional counter.

Results

Table 1 presents December 1963 results of alpha and beta analyses of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the System's Annual Compilation of Data (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero and when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter. The most recent quarterly strontium–90 results appeared in the January 1964 issue of *RHD* (*10*).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the December 1963 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957–1962 have been summarized by Weaver *et al* (*11*).

Discussion

The monthly dissolved beta activity averages exceeded 200 pc/liter only on the Columbia River. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 148 and 866 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility.

The dissolved alpha activity, which is associated with the dissolving of natural surface minerals by water, ranged in monthly averages

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, DECEMBER 1963

(Average concentrations in pc/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsbugh, Pa	4	11	15	0	0	0
Animas River:						
Cedar Hill, N. Mex	2	11	13	<1	3	3
Apalachicola River:						
Chattahoochee, Fla	2	9	11	0	0	0
Arkansas River:						
Coolidge, Kansas	9	45	54	1	51	52
Ponca City, Okla	0	20	20	0	4	4
Fort Smith, Ark	6	28	34	0	3	3
Little Rock, Ark	3	15	18	0	1	1
Pendleton Ferry, Ark	7	22	29	1	2	3
Bear River:						
Preston, Idaho	5	13	18	0	2	2
Big Horn River:						
Hardin, Mont	8	25	33	1	8	9
Big Sioux River:						
Sioux Falls, S. Dak	4	26	30	0	5	5
Chattahoochee River:						
Atlanta, Ga	6	9	15	0	0	0
Columbus, Ga	3	11	14	0	0	0
Lanett, Ala	8	9	17	1	0	1
Chena Slough:						
Fairbanks, Alaska	1	3	4	0	0	0
Clearwater River:						
Lewiston, Idaho	3	8	11	0	0	0
Clinch River:						
Clinton, Tenn	1	13	14	0	0	0
Kingston, Tenn	9	110	119	0	<1	<1
Colorado River:						
Loma, Colo	8	24	32	1	5	6
Page, Ariz	2	40	42	0	8	8
Boulder City, Nev	0	18	18	0	5	5
Parker Dam, Calif-Ariz	1	18	19	0	11	11
Yuma, Ariz	1	32	33	0	3	3
Columbia River:						
Northport, Wash	2	11	13	0	1	1
Wenatchee, Wash	1	12	13	0	1	1
Pasco, Wash	54	866	920	0	<1	<1
McNary Dam, Ore	26	381	407	0	1	1
Bonneville, Ore	16	315	331	0	1	1
Clatskanie, Ore	17	148	165	0	<1	<1
Connecticut River:						
Wilder, Vt	4	13	17	0	0	0
Northfield, Mass	9	10	19	0	0	0
Enfield Dam, Conn	3	13	16	0	0	0
Cumberland River:						
Clarksville, Tenn	7	31	38	1	4	5
Cuyahoga River:						
Cleveland, Ohio	1	31	32	0	0	0
Delaware River:						
Martins Creek, Pa	8	10	18	0	0	0
Trenton, N. J	5	10	15	0	0	0
Philadelphia, Pa	7	12	19	0	0	0
Escambia River:						
Century, Fla	4	16	20	0	0	0
Great Lakes:						
Duluth, Minn	2	3	5	0	0	0
Sault Ste. Marie, Mich	1	6	7	0	0	0
Milwaukee, Wisc	0	6	6	0	0	0
Gary, Ind	0	8	8	0	0	0
Port Huron, Mich	2	9	11	0	0	0
Detroit, Mich	1	7	8	0	0	0
Buffalo, New York	12	21	33	0	0	0
Green River:						
Dutch John, Utah	2	25	27	0	1	1
Hudson River:						
Poughkeepsie, N. Y	1	16	17	0	0	0
Illinois River:						
Peoria, Ill	10	17	27	1	0	1
Grafton, Ill	51	22	73	9	2	11
Kanawha River: Winfield Dam, W. Va	4	8	12	0	1	1
Kansas River:						
De Soto, Kansas	9	40	49	1	2	3
Klamath River:						
Keno, Oreg	5	13	18	0	0	0
Little Miami River:						
Cincinnati, Ohio	3	10	13	0	1	1
Maumee River:						
Toledo, Ohio	4	21	25	0	1	1
Merrimack River:						
Lowell, Mass	3	15	18	0	0	0
Mississippi River:						
St. Paul, Minn	2	23	25	0	2	2
Dubuque, Iowa	3	18	21	0	0	0
Burlington, Iowa	5	18	23	0	1	1
E. St. Louis, Ill	5	23	28	0	1	1
Cape Girardeau, Mo	4	26	30	0	3	3
W. Memphis, Ark	6	17	23	0	1	1
Vicksburg, Miss	16	17	33	3	1	4
Delta, La	9	21	30	0	1	1
New Orleans, La	0	21	21	0	1	1
Missouri River:						
Williston, N. Dak	16	19	35	2	3	5
Bismarck, N. Dak	2	24	26	0	3	3
Yankton, S. Dak	7	23	30	1	3	4
Omaha, Nebr	2	25	27	0	6	6
St. Joseph, Mo	3	20	23	1	4	5
Kansas City, Kans	11	34	45	1	7	8
Missouri City, Mo	12	25	37	3	5	8
St. Louis, Mo	7	28	35	0	5	5
Monongahela River:						
Pittsburgh, Pa	1	15	16	0	0	0
North Platte River:						
Henry, Nebr	7	42	49	1	28	29
Ohio River:						
Toronto, Ohio	2	12	14	0	0	0
Addison, Ohio	2	13	15	0	1	1
Huntington, W. Va	4	14	18	0	0	0
Cincinnati, Ohio	3	15	18	0	0	0
Louisville, Ky	1	20	21	0	1	1
Evansville, Ind	1	13	14	0	1	1
Cairo, Ill	4	13	17	1	1	2
Ouachita River:						
Bastrop, La	9	18	27	1	1	2
Pend Oreille River:						
Albeni Falls Dam, Idaho	2	7	9	0	1	1
Platte River:						
Plattsmouth, Nebr	11	27	38	1	6	7
Potomac River:						
Williamsport, Md	5	10	15	0	0	0
Great Falls, Md	6	13	19	0	0	0
Washington, D.C	5	12	17	<1	0	<1
Rainy River:						
Baudette, Minn	7	25	32	0	0	0
International Falls, Minn	6	30	36	0	0	0
Raritan River:						
Perth Amboy, New Jersey (5-ft. Below Surface)	7	15	22	0	4	4
Perth Amboy, New Jersey (5-ft. Above Bottom)	3	13	16	0	5	5
Red River, North:						
Grand Forks, N. Dak	2	58	60	0	2	2
Red River, South:						
Denison, Tex	1	37	38	0	0	0
Index, Ark	1	28	29	0	0	0
Bossier City, La	5	24	29	1	4	5
Alexandria, La	7	35	42	0	3	3
Rio Grande River:						
Alamosa, Colo	2	11	13	0	1	1
El Paso, Tex	3	19	22	0	2	2
Laredo, Tex	13	15	28	1	6	7
Brownsville, Tex	7	31	38	1	4	5
Roanoke River:						
John H. Kerr Resr/Dam, Va	3	9	12	0	0	0
Sabine River:						
Ruliff, Tex	11	21	32	1	1	2
Sacramento River:						
Courtland, Calif	4	6	10	0	0	0
St. Lawrence River:						
Massena, N. Y	9	23	32	1	8	9
San Joaquin River:						
Vernalis, Calif	2	13	15	0	1	1
San Juan River:						
Shiprock, N. Mex	5	16	21	0	2	2
Savannah River:						
North Augusta, S. C	4	12	16	0	0	0
Port Wentworth, Ga	5	14	19	0	0	0
Schuylkill River:						
Philadelphia, Pa	4	11	15	0	0	0
Shenandoah River:						
Berryville, Va	1	8	9	0	1	1
Ship Creek:						
Anchorage, Alaska	1	2	3	0	0	0
Snake River:						
Ice Harbor Dam, Wash	1	12	13	0	3	3
Wawawai, Wash	5	9	14	0	3	3
Payette, Idaho	4	13	17	0	5	5
South Platte River:						
Julesburg, Colo	18	84	102	2	42	44
Spokane River:						
Post Falls, Idaho	0	6	6	0	0	0
Susquehanna River:						
Sayre, Pa	12	7	19	1	0	1
Conowingo, Md	5	12	17	0	0	0
Tennessee River:						
Lenoir City, Tenn	5	7	12	0	0	0
Chattanooga, Tenn	1	18	19	0	<1	<1
Bridgeport, Ala	1	16	17	0	0	0
Pickwick Landing, Tenn	3	11	14	0	0	0
Tombigbee River:						
Columbus, Miss	13	15	28	1	0	1
Truckee River:						
Farad, Calif	4	9	13	0	0	0
Verdigris River:						
Nowata, Okla	2	30	32	0	2	2
Wabash River:						
New Harmony, Ind	4	17	21	0	0	0
Willamette River:						
Portland, Oreg	0	2	2	0	0	0
Yakima River:						
Richland, Wash	2	6	8	1	1	2
Yellowstone River:						
Sidney, Mont	6	44	50	0	9	8
Maximum	54	866	920	9	51	52
Minimum	0	2	2	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (6).

to 51 pc/liter. Of all stations, four on different rivers had monthly average dissolved alpha activity between 10 and 51 pc/liter.

While there are no generally applicable standards for surface water, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*12*). The Public Health Service Drinking Water Standards state that in the absence of strontium–90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*13*).

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(*2*) *Ibid.*, 1959 Edition. Price $1.75.
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(*8*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).
(*9*) Harley, J. H.: Radiochemical Determination of Strontium–90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, U. S. Atomic Energy Commission, New York Operations Office (1962).
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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium–90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

RADIOACTIVITY IN MINNESOTA SURFACE WATER SUPPLIES,[1] JULY–DECEMBER 1963

Division of Environmental Sanitation, Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled, but 7 surface streams and lakes involving 9 stations are now sampled routinely (see figure 1). "Grab" samples of raw and treated water are collected weekly at each station. No raw water is collected from the Minneapolis supply.

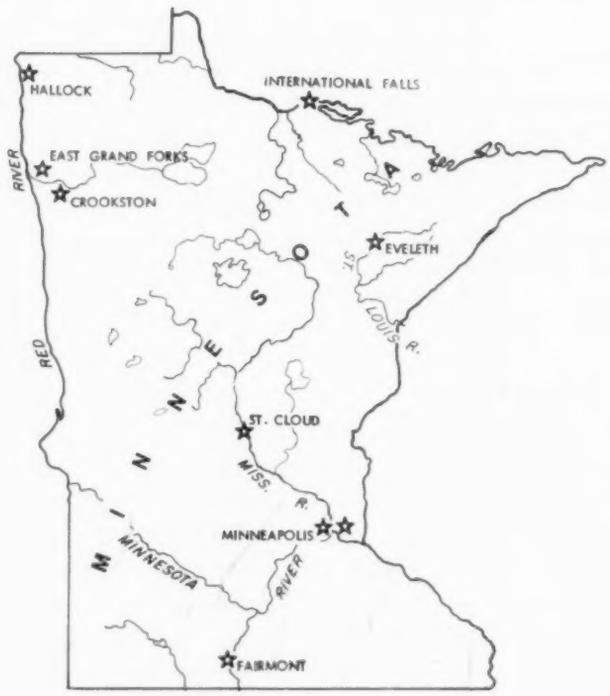

FIGURE 1.—SURFACE WATER SAMPLING LOCATIONS

[1] Data and information from "Survey of Environmental Radioactivity, October-December 1963, State of Minnesota Department of Public Health, University Campus, Minneapolis 14, Minnesota 55440.

The samples are forwarded to the Division's Laboratory where they are analyzed for gross beta activity. A 500-ml sample of water is evaporated at 75° C from a planchet. The solid residue (suspended plus dissolved solids) is fixed by adding lucite in acetone. Afterwards, this sample is counted with an internal proportional counter. Counter standardization is accomplished by adding known amounts of thallium–204 standard to solutions containing the normal range of solids.

Table 1 shows the monthly average gross beta activity in Minnesota surface water from July-December 1963. The minimum detectable level is a convenient low value not normally exceeded by one standard deviation; this is 15 pc/liter at present. In averaging, the value 7 pc/liter is used for samples having less than the minimum detectable value.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variation in precipitation and flow rates of streams could contribute to this variation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from <15 to 118 pc/liter. Treated water in most cases contained less beta activity than the corresponding raw water.

Previous coverage in *Radiological Health Data:*

Period	Issue
October 1957-August 1959	*April 1960*
August 1959-April 1962	*August 1962*
April 1962-November 1962	*April 1963*
December 1962-June 1963	*November 1963*

TABLE 1.—TOTAL BETA CONCENTRATION IN MINNESOTA RAW AND TREATED WATER FROM SURFACE SUPPLIES, JULY–DECEMBER 1963

[Monthly average concentrations in pc/liter]

Town and water source	Type of water	July	August	September	October	November	December
Crookston, Red Lake River	Raw	[a]—	60	21	28	28	20
	Treated	—	47	21	25	15	<15
East Grand Forks, Red Lake River	Raw	118	64	46	21	32	22
	Treated	40	35	15	<15	30	<15
Eveleth, St. Mary's Lake	Raw	56	67	47	31	39	22
	Treated	49	52	45	23	34	24
Fairmount, Budd Lake	Raw	36	59	40	32	39	45
	Treated	55	22	31	<15	33	15
Hallock, Two Rivers South Fork	Raw	86	77	78	59	57	38
	Treated	51	38	37	40	51	<15
International Falls, Rainy River	Raw	89	—	40	<15	—	27
	Treated	62	—	17	<15	—	<15
Minneapolis Tap Water	Raw	—	—	—	—	—	—
	Treated	48	23	<15	<15	26	<15
St. Cloud, Mississippi River	Raw	—	42	—	<15	—	<15
	Treated	—	48	—	<15	—	<15
St. Paul, Vadnais Chain of Lakes	Raw	47	64	29	32	28	21
	Treated	36	28	<15	<15	21	<15

[a] Dash indicates no sample.

Section IV—Other Data

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC contractor installations have appeared periodically in *RHD* since November 1960. Following are reports for Knolls Atomic Power Laboratory (KAPL) and the S1C Prototype Reactor Facility, summarizing the results for the 18-month period July 1962-December 1963.

Releases of radioactive materials from these plants for the periods covered in the reports below may be compared with standards set forth in the Federal Register, Title 10, Part 20. The appropriate concentration standards are given in table 1.

TABLE 1.—CONCENTRATION STANDARDS PERTAINING TO ENVIRONMENTAL MONITORING AT KAPL AND S1C [a]

Radionuclide	Air (pc/m³)	Water (pc/liter)
Total activity in air if α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present [b]	100	
Total activity in water if Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present [b]		3,000
Mn^{54}-Co^{58}	1,000	90,000
Fe^{59}	2,000	50,000
Co^{60}	300	30,000
Sr^{89}	1,000	10,000
Sr^{90}	10	100
Cs^{137}	500	20,000
Ce^{144}-Pr^{144}	300	10,000

[a] The concentration standards given here were taken from the Atomic Energy Commission's regulation 10CFR, Part 20 (Federal Register, November 17, 1960).

[b] "Not present" implies that the concentration of the nuclide is small compared with its appropriate MPC. According to Federal Register, Title 10, Part 20, August 9, 1961, a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than $\frac{1}{10}$ and if the sum of these ratios for the group in question is equal to or less than $\frac{1}{4}$.

1. Knolls Atomic Power Laboratory, July 1962-December 1963

General Electric Company, Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Commission in the development of atomic power reactors for naval propulsion. This includes design, construction and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site, located as shown in figure 1. The Knolls site occupies approximately 170 acres upon which are located administrative buildings; chemistry, physics, metallurgical, engineering and radioactive materials laboratories; critical assembly buildings; machine shops; decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building and waste treatment facility.

Air Monitoring

Environmental airborne radioactivity is measured at three locations on the Knolls site, four locations on the West Milton site and at the General Electric Company Research Laboratory, approximately one mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis.

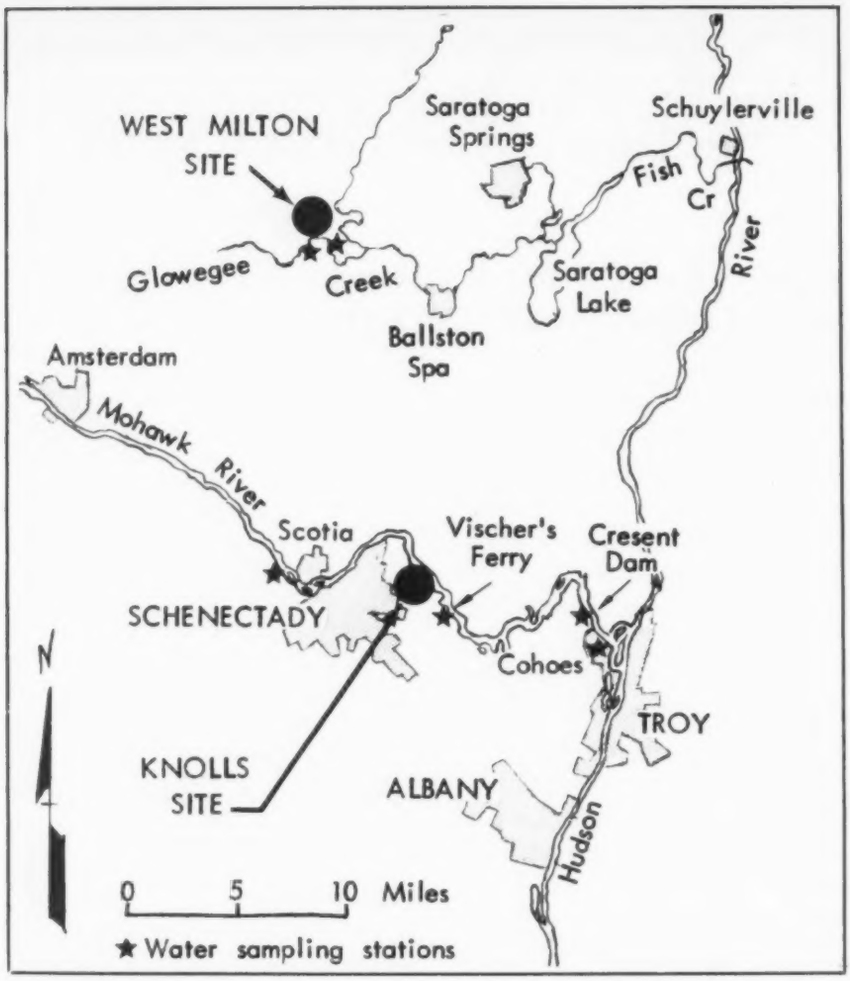

FIGURE 1.—ENVIRONMENTAL MONITORING LOCATIONS, KAPL

The results of the airborne radioactivity analyses are given in table 2. Measurements of airborne radioactivity are made at least 48 hours after collection allowing the naturally occurring short-lived materials to decay.

TABLE 2.—AIRBORNE BETA ACTIVITY, KAPL

[Average concentrations in pc/m³]

Sampling locations	Second half 1962	First half 1963	Second half 1963
Knolls site	4.03	6.18	2.93
West Milton site	5.49	9.20	2.97
Off-site	3.95	6.37	2.59

Liquid Waste Monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated according to the concentration of fission products in the collection tanks and the flow of the river. A continuous proportional sample of the Knolls Site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium–90 is the principle component to be considered in control. The amounts and the radioistopic content of the combined sewer effluent discharged from the Knolls site have been summarized in table 3. A total of

TABLE 3.—RADIONUCLIDE CONCENTRATIONS IN THE KNOLLS SITE WASTE EFFLUENT, KAPL

[Average concentrations in pc/liter]

Radionuclides	Second half 1962	First half 1963	Second half 1963
Sr^{89}	14,000	28,000	7,000
Sr^{90}	1,400	16,000	18,000
Cs^{137}	45,000	45,000	25,000
Ce^{144}-Pr^{144}	32,000	43,000	17,000
Gross beta	110,000	140,000	67,000

54.8 curies of beta activity was discharged to the Mohawk River during the 18-month period of this report.

Mohawk River water is sampled continuously at the General Electric Company powerhouse eight miles upstream from the Knolls site, and the Vischer Ferry powerhouse approximately two miles downstream. Samples taken from the Cohoes pumping station approximately thirteen miles downstream show very nearly the same average concentrations obtained for the Vischer Ferry samples shown in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN STREAMS RECEIVING EFFLUENTS, KAPL

[Average concentrations in pc/liter]

Stream and location	Second half 1962	First half 1963	Second half 1963
Mohawk River (Knolls site):			
G.E. Powerhouse (upstream)	11	19	12
Vischer Ferry (downstream)	15	15	21
Glowegee Creek (West Milton site):			
Upstream	24	41	16
Downstream	27	30	18

Since the Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of 0.017 curies was discharged at two points into Glowegee Creek during the 18-month period at monthly average concentrations ranging from 6 to 440 pc/liter.

Samples of the Glowegee Creek water are taken once a week at two locations, 150 feet above the point where the S3G effluent enters the stream, and the other 2,640 feet below the S3G discharge or 1500 feet below the D1G discharge.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*September 1961*
First and second quarters 1961	*March 1962*
July 1961-June 1962	*July 1963*

2. S1C Prototype Reactor Facility July 1962-December 1963

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land based nuclear submarine power plant facility, operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, at Windsor, Connecticut. The Prototype contains a pressurized water reactor power plant which is used for research, development and training.

Essentially all of the radioactive wastes originate from activation of minute amounts of impurities and corrosion products in the circulating water used as a reactor coolant. Ventilation air from the submarine hull and the supporting facility is continuously monitored at the exhaust stack. Liquid wastes are monitored before discharge to the Farmington River. Tables 5 and 6 give the average beta concentrations of airborne and liquid wastes before release to the environment.

TABLE 5.—AIRBORNE BETA ACTIVITY, S1C

[Average concentrations in pc/m³]

Sampling location	Second half 1962	First half 1963	Second half 1963
Stack discharge	46	54	59
On-site downwind from stack	8.3	9.0	8.4
On-site average [1]	—	—	2.2
Off-site average [1]	—	—	3.0

[1] These samples were not collected until second half 1963.

TABLE 6.—RADIOACTIVITY IN LIQUID WASTES DISCHARGED INTO THE FARMINGTON RIVER, S1C

Activity	Second half 1962	First half 1963	Second half 1963
Total beta activity (curies)	0.020	0.021	0.010
Average gross beta concentrations (pc/liter):	4,300	4,900	2,000
Co^{60}	3,300	3,700	5,200
Fe^{59}	290	670	870
Mn^{54}-Co^{58}	1,300	950	1,900

Figure 2 shows the locations of six water sampling stations along the Farmington River and of 17 fallout monitoring stations. A more detailed description of S1C Prototype Reactor Facility and its control measures is available in the September 1961 issue of *Radiological Health Data.* Comparisons of the data for up-

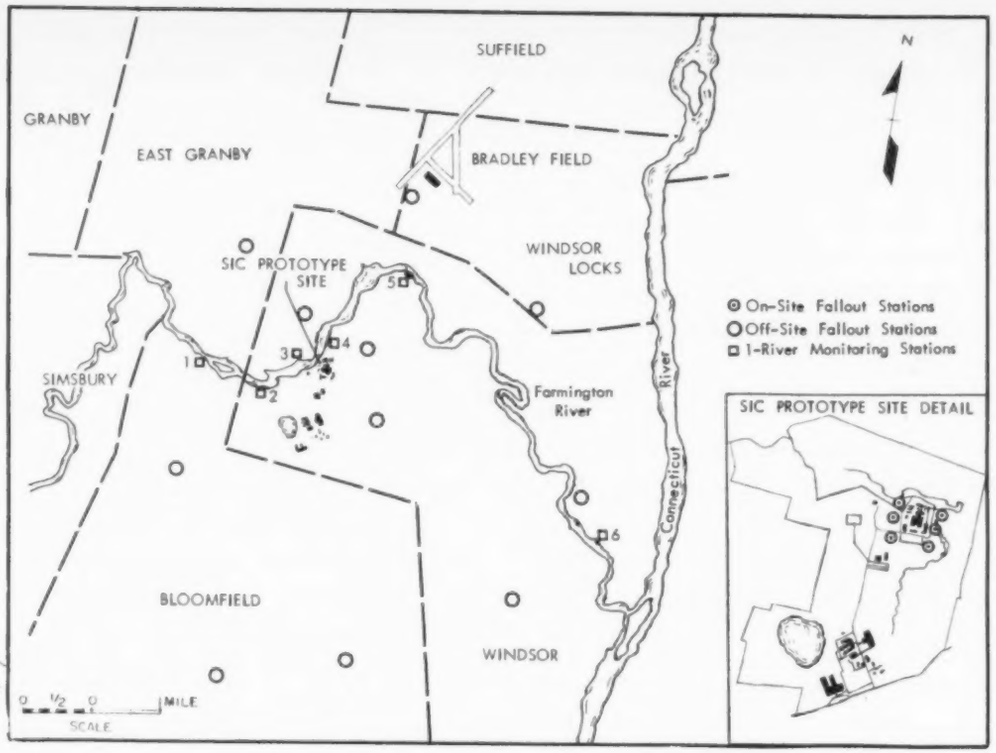

FIGURE 2.—ENVIRONMENTAL MONITORING LOCATIONS, SIC PROTOTYPE SITE

stream and downstream samples appear in table 7. Comparisons of on-site and off-site fallout samples appear in table 8.

TABLE 7.—BETA ACTIVITY IN THE FARMINGTON RIVER, SIC

[Average concentrations in pc/liter]

Sampling station numbers (*See figure 2*)	Second half 1962	First half 1963	Second half 1963
Upstream:			
1	18	30	160
2	14	[a]—	—
Outlet:			
3	14	12	99
Downstream:			
4	14	—	—
5	14	23	62
6	15	33	57

[a] Dash indicates sampling discontinued.

TABLE 8.—BETA ACTIVITY IN FALLOUT, SIC

[Average deposition in nc/m^2/month]

Locations	Second half 1962	First half 1963	Second half 1963
On-site (6 stations)	44.65	61.57	[a] 26.55
Off-site (11 stations)	56.80	55.46	[a] 79.83

[a] These averages represent 29 on site samples and two off-site during the period July 1–24, 1963, after which fallout sampling was discontinued.

Previous coverage in *Radiological Health Data:*

Period	Issue
January-March 1960	*November 1960*
April-June 1960	*January 1961*
July-December 1960	*September 1961*
January-July 1961	*March 1962*
July 1961-June 1962	*July 1963*

REPORTED NUCLEAR DETONATIONS, MAY 1964

Two low-yield underground nuclear tests conducted during May 1964 at the Nevada Test Site were announced by the Atomic Energy Commission. (Low yield range is defined as equivalent to less than 20 kilotons of TNT.) Tests conducted on May 14 and May 15 were assigned arbitrary *Radiological Health Data* reference numbers 156 and 157, respectively.

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UNITS AND EQUIVALENTS

Symbol	Unit	Equivalent
Bev	billion electron volt	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc $=10^{-9}$ curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 $m\mu c/m^2$ = 1,000 $\mu\mu c/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 μμc = 10^{-12} curies
r	roentgen	
μμc	micromicrocurie	1 μμc = 2.22 dpm

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	ter' a
10^{9}	giga	G	ji' ga
10^{6}	mega	M	meg' a
10^{3}	kilo	k	kil' o
10^{2}	hecto	h	hek' to
10	deka	da	dek' a
10^{-1}	deci	d	des' i
10^{-2}	centi	c	sen' ti
10^{-3}	milli	m	mil' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	nan' o
10^{-12}	pico	p	pe' co
10^{-15}	femto	f	fem' to

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